GUIDING PRINCIPLES IN SURGICAL PRACTICE

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PREFACE.

In offering this monograph which embodies some of the guiding principles in surgical practice, I realize that it expresses only an individual viewpoint. To have reflected on a safe and logical working method, is a vital prerequisite in surgical training. If, in any case, this outline, which is derived chiefly from clinical study, has helped to supply a system where there was none, the tedious task of formulating it will have been worth while.

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CHAPTER I

General Considerations

Good surgical judgment, logical asepsis, dexterous technic are three requirements that are of principal importance in the practice of surgery. But, while *surgical judgment* must gradually mature, it can be supplied, to some extent, by the careful study of one's work, and, by consulting with others of greater experience. *Dexterity* in executing an operation can only come with frequent repetition of a definite technic. It will be acquired sooner by him whom the hospital entrusts with the surgical care of its numerous poor, than by the colleague who has to rely on his private practice alone for a repetition of similar cases. Finally, the preservation of a *logical asepsis* throughout the course of an operation involves the surgeon's attention and solicitude in many directions. Wound contamination may be traceable to faulty or deficient local preparation of the territory for operation, or to the hands of the operator, or to one of his assistants or nurses, or to the instruments he uses, or the suture material; it may be an operating-room basin or utensil that is not surgically clean; or gauze or wound-dressings or contact with unsterile wash; or, most important of all, *injudicious handling of a bacterial nidus existing in the living structures which come within the compass of the operation.* While acting in the interest of his patient's future physical well-being, the surgeon as-

Surgical Judgment

Dexterous Technic

Logical Asepsis

sumes all the responsibility for the outcome of his measures, and for any violation of asepsis by those delegated to assist him. No matter therefore, how exacting he may be during the tension of his work, he is always entitled to alert and faithful cooperation.

There would be little difference between the surgeon and the assassin, if the wound were not inflicted in the hope of bettering the patient's physical condition. No operation which is not urgent, should be undertaken before the safety of the surgical measure has been duly weighed. Most cases of post-operative death are due to infection. The sources of danger in operating are two-fold, extrinsic and intrinsic. With the strict present day regime, in the preparation of the patient, and in the operating-room service, infection which is due to *extrinsic* causes has become systematically avoidable. Most major complications and deaths which occur after operation are due to infection which is *intrinsic* in origin. The difficulty arises out of the fact that it is hard to deal with infected structures, without disseminating infection. Bacterial foci may be normally present within the body; thus in the alimentary canal or the genito-urinary tract. Although aseptic in the new-born, pathogenic bacteria very soon gain access to the bowel; and, at a later date, with the advent of sexual maturity, the genito-urinary tract is prone to lose its relatively aseptic character. Any technic which involves the opening of these hollow organs during the course of an operation, is at once fraught with additional risks. In a strictly aseptic case, that is one in which the temperature is absolutely normal before operation, these are among the chief avenues of danger from

Extrinsic and Intrinsic Infection

intrinsic infection. But when the case is primarily not an aseptic one, as indicated by the preoperative temperature, then the problem becomes encumbered by the presence of a bacterial herd at the site of disease and perhaps permeating the very structures which are involved in the operation. Because the outskirts of disease about an infected focus are not always plainly demarcated, the surgeon's instruments and hands become contaminated while dividing tissues which he assumes to be sterile. Besides the risk of transplanting germ-life from one structure to another, if the lymph stasis or hemostasis is not perfect and efficient drainage is not employed, the accumulating fluid may prove to be a fertile culture medium for the remaining bacteria and lead to peritonitis or sepsis. Experience has taught that hysterectomy for cancer of the cervix cannot be safely undertaken without drainage. The cancerous area is nearly always invaded by a varied bacterial flora and the paracervical and parametrial cellular tissues are not often clean.

Preoperative Fever

While the presence of preoperative fever indicates that the case is not a strictly aseptic one, it must be borne in mind that the absence of a temperature rise just before operation is not always equally significant. Indeed, in the course of a thrombo-phlebitis, there may be afebrile intervals of shorter or longer duration; a few days' record of preoperative temperature may be misleading, and operation performed under the impression that the case is a clean one, may be attended by post-operative embolism. Endocarditis may be similarly latent and afebrile for short periods, although even slight perturbations should arouse suspicion and an examination of the blood may at once reveal an over-

whelming leucocytosis and high polymorphnuclear cell percentage.

Working Rules

From this brief consideration can be gleaned two valuable working rules. Firstly, never to urge an operation which can be circumvented and is not imperative, when the patient has not an absolutely normal temperature before operation. Secondly, when several methods of operating come in question, to give preference to those in which intrinsic infection of the wound is least likely to occur.

CHAPTER II

Preparation of the Patient for Operation

The patient, properly prepared for operation under general anesthesia, should, as a rule, have no digesting food in the stomach, and the large bowel should be emptied; but this does not mean that she should be translated into a state of hunger. A starving patient is more likely to suffer ill-effects from the anesthetic, and recovery from the operation itself is less assured. Finally, the field of operation is to be rendered surgically clean, in order to exclude the introduction of pathogenic organisms from without into the wound which the surgeon inflicts—extraneous or extrinsic infection. This is done in the primarily aseptic case as well as that which is not. The problem resolves itself into the consideration of the sterilization of the skin, and the sterilization of the mucous membrane. In a general way, the procedures followed in making the skin surgically clean for operation, may be grouped under two headings: those which depend on *mechanical cleansing,* and those which are based on *chemical disinfection.* Although with the exercise of due precaution, both procedures have yielded good results, both nevertheless present inadequacies which should not be overlooked in the search for *methods which are simple in their application and, at the same time, uniformly reliable.*

General and Local Preparation

Cleansing and Disinfection

There is the well founded objection to the usual mechanical cleansing methods, that besides being time-consuming, the microscopic recesses of the

skin cannot become thoroughly accessible to the crude scrubbing manoeuvres. On the other hand, the disinfecting methods which are commonly employed, for instance, those which consist in applying two coats of tincture of iodine to the skin, one before, and one at the time of operation, provide no satisfactory safeguard against intermediary contamination of the operating field. In other words, the final coat of iodine is allowed only few minutes time during which to exert its disinfectant action before the operation begins. Can this mean trustworthy sterilization when the field has been recently soiled?

Objections to these Methods

Notwithstanding these and other objections, both methods have proven to be comparatively safe when carried out under the strict present day hospital regime, at least as far as the more serious consequences of an insufficient surface asepsis are concerned. But in these conclusions, minor perturbations in the aseptic rise due to a slight stitch involvement, or delayed infections, have been largely disregarded. Moreover, *almost any method of preparation will appear to be satisfactory where the field of operation was not seriously contaminated with bacteria, above all with spore-forms.* It is with a view of eliminating some of the weak points of the mechanical cleansing and chemical disinfecting methods, that these have been variously combined—*combined methods.* In such a combined method, the disinfectant can be applied early to give it sufficient time to act, while the cleansing measures immediately precede the operation.

Combined Methods

In one of these methods tincture of iodine (3½%) is applied to the dry skin over night, and followed by the soap-suds—sterile water—alcohol

sequence before operation. This represents a safe routine when conscientiously carried out; perhaps better, in the long run, than either the method by mechanical cleansing with soap and water or that by disinfection alone. But the proper execution of the many fluid rounds of the old soap and water sequence demands more alertness than it often receives from the assistant to whom it is entrusted. The question therefore naturally arises if the soap and water cannot be altogether dispensed with, and supplanted by a single cleansing solution.

The following formulae and procedure represent the net result of my efforts since 1908 to develop such a *combined method* which is comparatively simple and safe. In its application two solutions are necessary:

Liquor Disinfectans—Solution No. 1.

Rp. Iodine crystals, 3.5.
Alcohol U. S. P.
Carbon tetrachloride.
āā ad. 100.0.

D. Keep in a dark glass-stoppered bottle.
S. Disinfecting solution for the skin.

Liquor Expurgans—Solution No. 2.

Rp. Methyl Salicylate, 1.0.
Carbon tetrachloride.
Alcohol U. S. P.
āā ad. 100.0

D. S. Cleansing solution for the skin.

On the day before operation, unless contraindicated, the patients receive a cleansing bath with soap and warm water. This removes the desqua-

mating surface epithelium and exposes a cleaner substratum. The area for operation is then shaved, washed free of all traces of soap, well dried with a sterile towel and protected with a cover of sterile gauze. On the evening before operation the nurse swabs the surface with Liquor Disinfectans—Solution No. 1—in sufficient quantity to produce a deep brownish-yellow stain. Hairy or sebaceous areas, creases and folds in the skin, and the umbilicus require particular attention. Sterile gauze protects the surface and is securely held in place by zinc oxide adhesive strips.

In the operating-room a single washing of the abdomen with Liquor Expurgans—Solution No. 2—and drying of it with a sterile towel is all that precedes the incision.

Principles Involved.

In this routine the patient's cleansing bath first removes the altered, acid sweat with admixed fatty acids—formic, acetic, propionic, butyric, caproic, capric—which stagnate upon the surface of the skin; and allows it to be replaced by a fresh, more or less alkaline secretion from the sudoriparous glands. There is an interval after the bath, so that the skin has time to become dry by evaporation before the disinfecting solution is used. The compatibility of the disinfectant with the heterogeneous secretion of the skin is increased, by modifying the alcoholic menstruum in which it is dissolved, with an equal part of the fat-solvent carbon tetrachloride.

The pure tincture of iodine which consists only of iodine crystals dissolved in 95% alcohol, such as the Tinctura Iodi, U. S. P., 1890, is relatively incompatible with water. Traces of moisture, however, can be attracted by the alcohol without throwing the iodine out of solution. If potassium iodide

is added, the iodine becomes at once freely water-soluble. This is the principle on which Lugol's iodine solution, Liquor Iodi Compositus, U. S. P., is based. When iodine gains entrance to a sweat gland, it is probably attracted by the alkalinity of the secretion from the deeper recesses of the gland and in small part, converted into water-soluble iodide—thus it might be said that the duct of the sweat gland represents a miniature test-tube in which minute quantities of Lugol's solution are formed.

In considering skin disinfection it is in point to regard the sweat which is supplied by the sudoriparous glands, as distinctly *fatty,* and not as purely aqueous. Moreover, the function of supplying the fatty secretion of the skin does not seem to be restricted solely to the sebaceous glands; thus, neutral fats—palmitin and stearin—have been found in the sweat of the palm of the hand where no sebaceous glands exist, as well as in the perspiration generally. In addition the elaboration of fatty bodies has been demonstrated to take place in small part, hand in hand with keratin-formation, in the epithelial cells of the cornifying layers of the epidermis itself. Sweat may therefore be correctly classed as a fatty secretion. But an *aqueous* solution such as Lugol's Iodine would be incompatible with fatty bodies. On the other hand, the pure tincture fails in penetrating power because alcohol is not a fat-solvent. For this reason, when iodine is not employed in a fat-solvent vehicle, particular stress has to be laid on the removal of the inspissated fatty secretion from the skin beforehand. Especially is this true, where the abdominal incision encroaches upon the hairy zone of the pubes.

Fatty Nature of Sweat

If, however, the disinfectant solution is of itself capable of penetrating fatty bodies as in the formula of the method which has been outlined, such a preparatory step becomes unnecessary.

Cleansing Instead of Disinfection?

Finally, instead of repeating the disinfection of the field in the operating room *where even the most powerful agent is scarcely given time to exert its full germicidal action* recourse is had to a simplified cleansing method instead. This procedure may not appeal to those who endorse the radical iodine method, but for my own part, I am inclined to base more reliance on operating-room methods which have in view the *removal* of bacteria by mechanical cleansing, than on those which aim to *destroy* them by a single disinfection immediately before operation. However, no cleansing solution, whatever its chemical nature, can substitute soap and water and at the same time make *the act of cleansing itself* redundant.

In *emergency cases,* it is not infrequently necessary to perform an operation on short notice, and sometimes the only preparation the patient can receive has to be given in the operating room before operation. There may have been no preliminary cleansing bath to aid in making the territory germless. In such cases, naturally, combined methods are not applicable. The question arises what should, in such event, be the preparation of election. The advocate of the radical iodine method who is satisfied with a single application of the disinfectant, previous to operation, is not required to modify his plan of procedure in an emergency case. A single coat of the full or half strength tincture of iodine is applied to the skin of the abdomen, or to the resistant vaginal mucous membrane

Emergency Preparation

with equal readiness. But those who have some scruple as to the reliability of such disinfectant methods for routine work, will have to resort to one of the mechanical cleansing methods. There is the more complicated soap and water sequence of the older school; also the newer method of simple cleansing with a piece of soft soap and warm sterile water without any further embellishment. The effectiveness of this simple method in obtaining surgical cleanliness is not confined to the skin but extends, as well, to the mucous membrane. Lastly, warm, aqueous lysol 1–1000, combining antiseptic potency with the properties of a soap solution, is a very useful substitute, especially in the gynecological or obstetrical emergency operation.

Preparation of the Mucous Membrane

Because of the greater vulnerability of the mucous membranes, and the different character of their physiological secretions, methods suitable for the preparation of the skin need not necessarily be adequate for them. Disinfection with tincture of iodine, or cleansing with aqueous lysol, may be feasible in the case of the vagina of the multiparous patient, but it cannot be used in the cavity of the nose and mouth or in the bladder or rectum. The diseased, catarrhal mucous membranes may be bathed with an aqueous solution of tannic acid for varying periods before the operation is undertaken. Tannic acid precipitates the chief constituent of the mucus in the form of an insoluble tanno-proteid, and with it, the entangled bacteria; the deposited mucus is then readily washed away. A 1% solution of the acid in water is sufficient for ordinary purposes. But even a 50% aqueous solution *can* be employed without injury or toxic effect. Because it is neither poisonous nor

caustic, an aqueous solution of tannic acid can be used in the naso-pharynx, mouth, stomach, bowel, bladder, vagina, in the form of irrigations, in preparing a patient for operation. When prescribed as a vaginal douche for regular use, it is well to know that the fluid is apt to produce a bluish stain in linen with which it may come in contact. Metal instruments are not affected by it in an appreciable manner, so that it can be employed in the operating room as well as at the bedside.

NURSE'S OUTLINE OF PREPARATIONS FOR ABDOMINAL AND VAGINAL OPERATION.

Rectal temperatures before operation.
Urine analysis before operation.

Nurses' Outline of Preparations

10 A. M. Calomel, gr. iij given in a single dose.
Unless contraindicated allow the patient to have a general bath.
Shave the abdomen, pubes, vulva, inside of thighs; pubes closely.
Render the area clean by means of soap-suds and water, the umbilicus and pubes receiving particular attention.
Protect the abdomen with a sterile towel or gauze dressing.

12 A. M. Dinner. Selected diet.

4 P. M. Effervescent Magnesium Citrate, U. S. P., ℥ij.
Soap-suds enema until clear.
Vaginal douche, 1–1000 lysol, 1–1000 Lugol's iodine or 1–100 tannic acid solution, Cij.

6 P. M. Supper. Selected diet.

8 P. M. Soap-suds enema until clear.

Vaginal douche, 1–1000 lysol, 1–1000 Lugol's iodine or 1–100 tannic acid solution, Cij.

Apply a good coat of tincture of iodine or else Solution No. 1 to the abdomen and cover with a sterile dressing.

4 A. M. The patient receives some non-curdling drink if she is awake.

7.30 A. M. Morphine sulphate gr. ¼ subcutaneously.

Allow the patient to empty her bladder.

8 A. M. Ready for operation.

Procedure in the Operating Room

In the operating room the sterile dressing is removed and the abdomen is cleansed systematically with Solution No. 2 before the incision is made or a second coat of tincture of iodine, or else Solution No. 1 is applied instead. For vaginal operation, warm 1-1000 aqueous lysol or else soft soap and warm sterile water cleansing. To diminish the slipperiness of the mucous membrane, rinsing with tannic acid or zinc sulphate 1-100, or bichloride of mercury 1-1000, may follow the cleansing procedure.

The adoption of a system insures greater accuracy and facilitates clinical study, but the refrain that must come to every clinician who has been laboring industriously to systematize his work, is that no routine, however comprehensive, can be applied fitly to *every* case.

CHAPTER III

Sterile Wash and Wound Dressings

Sterilization of Dressings

It is scarcely more than twenty-five years that the *antiseptic* methods have been displaced by the *aseptic* treatment of wounds. Chemical solutions of sufficient strength to destroy bacteria, and even to inhibit their growth in a healing wound, become, at the same time, a serious menace to cell-development and proliferation, and interfere vitally with normal tissue repair. It was the full realization of this, that gradually led to the modern conception of aseptic surgery, and, in place of wound dressings saturated with powerful germicides, there was introduced everywhere, dry, unimpregnated gauze, sterilized by means of *thermic* instead of *chemical* methods.

Of the thermic methods of sterilization, the simplest is that by *boiling,* but in the case of operating-room wash and wound dressings where the material should be *dry* after sterilization, other methods had to be adopted. In the most practical and reliable of these, the materials are subjected to the sterilizing action of steam under pressure. Many apparatuses, some of them apparently quite complex, have been designed for this purpose; but the general principles upon which their construction is based, are essentially the same.

Sterilization by Steam Under Pressure

In the older models, the steam was admitted into the sterilizing space immediately, and there was no

particular device which insured the proper *preliminary warming* of its contents. The result was, that the parcels became damp or wet from the condensation of the superheated steam upon the cool surface. To correct this, the mantle of newer sterilizers consists of *two* cylinders, one within the other. The space *between* them can be filled with steam and is called the *steam-jacket space,* in distinction to the space *within* the inner of the two cylinders, the *sterilizing space.* After the nurse has packed the sterilizing space, the door of the sterilizer is closed and the steam-jacket space is filled with steam. As soon as the parcels have been warmed sufficiently, superheated steam is admitted to the sterilizing space itself, to take the place of the dry heated air which it contains.

Construction of the Sterilizer

When the sterilization is complete, the residual steam is removed from the compartment. To accomplish this, a separate valve-mechanism is attached to the sterilizer, by means of which the residual vapor can be disposed of by exhaustion. The same device also makes it possible to get rid of the warm air at the beginning of the sterilization process, without depending on the incoming steam to displace it. This provision effectively does away with the occasional wet bundles delivered from the older sterilizers, and insures thorough dryness of the wash and dressings after sterilization.

Briefly stated, the process of sterilization by steam under pressure involves the following steps:

Steps in Sterilization

I. Packing of the sterilizing space.

II. Warming of the wash to prevent condensation.

III. Exhausting the air and filling the compartment with steam.

IV. Permeation of the parcels by steam under a pressure of 15 pounds to the square inch, and at a temperature of 250° F. (121°C.) for 30 minutes.

V. Final drying of the parcels; the desiccation taking from 10 to 20 minutes.

The total time required for the work of sterilization in preparing for an operation may vary considerably, and usually exceeds an hour. But the time consumed by the actual sterilization itself, with the thermometer registering 250° F., and the manometer indicating a pressure of 15 pounds, *should never be less than 30 minutes.* Practically speaking, in hospital routine, the contents of each parcel have been subjected to the sterilization process twice before they are used at an operation. It is the practice to sterilize the contents of the parcels immediately after they have been made up to be put away in the parcel closet. When needed they are resterilized, and can then be taken directly from the sterilizer for use.

Time Required

One object of this double sterilization is to attack spores, which initially show considerable resistance. But liberated and made to germinate, these are more likely to be destroyed during the second sterilization. Fortunately, the pathogenic organisms which most commonly produce wound infection are *cocci,* streptococci, staphylococci, pneumococci, gonococci, and have no spore-forms; the bacillus pyocyaneus and colon bacillus are not

Reason for Resterilization

spore-bearing, while the tetanus bacillus which produces spores is of infrequent occurrence.

If any articles, such as towels or gloves, are known to have been soiled with pus, for example at an unclean operation, it is always wisest and safest to attend to their sterilization promptly, by boiling them. Ten to fifteen minutes in slightly alkaline or twenty to twenty-five minutes in plain water is adequate. When wanted again for operation these articles can be resterilized by steam under pressure in the usual manner, and a transferrence of pathogenic germs from one case to the other, need not be feared. The initial boiling is resorted to in such cases, because boiling is the simplest and most reliable of all methods of sterilization.

Disposal of Soiled Wash

The greatest scruple is necessary in case of the rubber gloves, because they come into the most intimate contact with the wound. A gauze drain is put into each glove in order to keep it from collapsing. As a rule, alkaline solutions are more apt to destroy the elasticity of the rubber gloves than plain water; but, if time is a factor, instead of using plain water, gloves *may* be boiled from 10 to 15 minutes in a 1-1000 aqueous solution of sodium hydrate (NaOH); in fact, this may be done a number of times before their texture is materially impaired, and the gloves become brittle and lose their elasticity. Ordinarily gloves are boiled in *plain* water from 20 to 25 minutes. After boiling they are at once thoroughly dried and powdered, and are then ready for resterilization by steam under pressure. In making rounds through the hospitals, a remarkable diversity of opinion can be gathered on this

Sterilizing Rubber Gloves

subject. There seems, however, no tenable reason why rubber gloves should not be *resterilized* by steam under pressure, in the same manner as the operating-room wash and wound dressings. Of course, during the steam sterilization, just as during sterilization by boiling, it is important that a gauze drain be placed into each glove so that the circulating steam can have access to its interior. Furthermore, stickiness or adhesion of the gloves is entirely obviated if the surfaces have been well powdered before they are subjected to the superheated vapor.

Time Required by Different Methods

In substituting one method for the other, the comparative time required for sufficient sterilization in each case, has to be borne in mind. It is indicated in the following table:

Boil in alkaline water (104° C.) 5-10-15 minutes.
Boil in plain water (100° C.) 20-25 minutes.
Steam at 250° F. (121° C.) 35 minutes.
Steam at 212° F. (100° C.) 45 minutes.

Parcels Must Be Permeable

With regard to the size of the parcels and the manner of packing the sterilizer, there are a few points which are of practical importance. The sterilizer should not be packed too tightly if the steam shall circulate freely between the parcels. To further facilitate penetration, the individual bundles, above all, if they are somewhat compact, should not be made larger than necessary. The parcel wrappers should be of strong cloth which is adequately porous; covers of rubber or of other impermeable materials, paper bags or envelopes, are never to be used as containers for anything that

is to be sterilized. The importance of this is not infrequently lost sight of in the sterilization of talcum-powder, which finds its way into the sterilizer in receptacles of wood, glass, tin or paper. Although these receptacles may be provided with small perforations at one end, the free access of the steam is unnecessarily impeded. The result may be insufficient sterilization of the contents, and the direct transferrence of pathogenic organisms to the wound. If the surgeon insists upon having talcum sterilized separately, *small* quantities of it should be put into pockets or bags of cloth. However, where stress is laid on powdering the rubber gloves properly before sterilization, and the surgeon takes time to dry his hands thoroughly with a sterile towel before attempting to put them on, the demand for an extra supply of talcum becomes redundant.

Sterile Talcum Powder

What should the sterilized bundles for the ordinary, uncomplicated laparotomy contain? The nurse has in readiness, a supply which is sufficient, firstly, for the patient, secondly, for the surgeon, assistants and nurses who help at the operation. In an interval operation for appendicitis, where only one assistant at the wound is needed besides the anesthetist, and one operating-room nurse who has charge of the instruments, suture material and gauze, the number of sterile gowns required is accordingly small. Desirable are gowns with long sleeves over the cuffs of which the rubber gloves can be drawn so that the arm is entirely covered. A very practical receptacle for sterile gowns, which is in use in some of the operating-rooms in this city,

Contents of the Sterilized Package

Operating Gowns

is a metal drum, the cover of which can be raised whenever a sterile gown is needed, by stepping on a pedal at the base of the stand on which it rests. As soon as the pressure with the foot is released, the lid of the drum again drops back into place.

Rubber Gloves

There should be seamless rubber gloves of the proper size to fit all those concerned in the operation. Their number should be ample to allow for one change for each assistant and nurse and, if occasion should demand, two for the surgeon. The asepsis can be logical only if gloves are worn throughout the entire operation, and by *all* who come in contact with the sterile materials and instruments. This means that the nurse who arranges the supply-table and consequently touches the sterile gauze, instruments and suture materials, can do this only with rubber gloves.

Laparotomy Sheet

The laparotomy sheet should be large enough to cover the whole patient, besides draping the operating table on each side; it has an opening over the field of operation. A T-shaped opening in the cloth is more serviceable for the various incisions than a longitudinal one. This is particularly apparent when a transverse incision, such as the semilunar hypogastric, is used by the surgeon.

Towels

After the laparotomy sheet is adjusted, four towels surround the wound site. There should be sufficient for one renewal, and an extra dozen for other needs. The surgeon asks for towels for his hands, a towel or two are wanted to dry the abdomen after the cleansing measures, another wraps the heft of the Pacquelin cautery. Where one nurse is able to take charge of the instruments and sterile

gauze, there is no advantage in covering more than one supply-table. Sterile gauze and towels, suture material, needles and needle-holders, Michel's clamps, retractors, forceps, clamps and hemostatics, and cutting instruments, can all be placed on one long, narrow table in orderly fashion, and kept separated from one another. When the surgeon prefers to pick the instruments himself, directly from a Hartley table which is pushed up close to the field of operation, a suitable cover or slip which fits the instrument-tray can be added to the sterilizer supply. A wet instrument should always be dried, before it is laid down upon the supply-table. If the cover, which often consists of a single layer of cloth, is accidentally saturated by dropping a bundle of wet suture material upon it, diffusion currents are set up at once from the surface of the unsterile glass plate beneath, to the suture which lies in the wet area. Such a suture is quickly soiled, and must be discarded. It is safest to put all the suture materials on a small tray of agate-ware which has been sterilized with the instruments for this purpose.

Arrangement of the Supply Table

There need not be a great variety of sterilized gauze. The tiny gauze sponges should be eliminated, since they are apt to be lost in the wound. It is better to cut very small pieces of gauze as occasion requires. The *gauze sponges* should be $2\frac{1}{2} \times 2\frac{1}{2}$ inches, and certainly not larger than 3×3 inches. The gauze should be so folded into a square, that the cut edge of it nowhere shows fraying with the liberation of little threads, or, unfolding does not take place while it is handled. It should be at least four-ply, so that, when it is

Gauze Sponges

folded diagonally—*delta sponge*—it is eight-ply. In this form it serves its purpose as a sponge most efficiently, which is chiefly to *imbibe* fluids—secretions, blood or pus. The delta sponge is picked up in such a manner that, to resort to geometrical verbiage, the blades of the long thumb forceps are parallel to the hypothenuse of this triangular piece of gauze. The nurse should understand this, since she may be asked to fix the sponges in the sponge-holder in this way, or else, to hand them to the surgeon's forceps individually.

Gauze Tampons

When more appreciable quantities of fluid have to be dealt with, as, for example, in the bursting of an abscess or cyst during operation, the gauze sponge may have to be replaced by pieces of gauze which have a greater bulk and proportionately increased imbibing power. Large pieces of gauze may also be called into play in exhausting a small transudate or exudate, or in removing accumulated blood. In the case of profuse oozing from an incision, as when operating for cancer of the breast, large pieces of gauze packed into the bleeding furrow, effect prompt hemostasis and prevent undue loss of blood. In a sudden venous hemorrhage in the depth of the abdomen or pelvis, where the injured vessel is not at once manifest, firm tamponade with large pieces of gauze, is the emergency measure. Rarely, and in modern surgery, only when this cannot be circumvented, a large piece of gauze may be inserted into the abdomen or pelvis, to "act as a drain"—really a foreign body around which adhesions of the intestinal loops rapidly form on account of the destruction of the surface endothelium, so that when the gauze is removed, in the

course of five to seven days, a securely walled-off canal or conduit remains, which leads down to the suspected focus. For all these exigencies larger pieces of gauze folded into four-ply tampons, 4 x 16 inches, and gathered into accordeon pleats—*accordeon gauze tampons*—can be fitly employed.

Besides gauze sponges and tampons, there are required in the ordinary laparotomy, about a dozen *abdominal pads*. These are intended only for walling-off the intestines, or for protecting the viscera from traumatism or contamination. The abdominal pad is also made of surgeon's gauze which is, however, sewn into a square, 12 x 12 inches, with a tail of cord or tape 2 inches long, and a metal ring attached to one of the corners. It is not intended to absorb secretions, and should not be bulky nor have a thick edge, and therefore consists of only three layers of gauze. The capillarity of the gauze, and the friction, make it a little difficult to introduce such a pad, but after it is finally placed in situ, it has the decided advantage that it is not as readily dislodged by the abdominal breathing, intestinal peristalsis, and the surgeon's manipulations, as a pad made of some smooth material would be. To facilitate the placing of an abdominal pad, the assistant should hold it up suspended by the ring, while the surgeon grasps the most dependent corner with the long thumb forceps in his right hand, holding the intestinal coils or viscus in question out of the way with the left.

Abdominal Pads

Although it is not imperative, it is practicable to have both the materials for cleansing the area of operation, and those used for the final dressing of

Gauze for Cleansing and Final Dressing

the wound, put up in separate parcels. For the scrubbing manipulations the assistant wears sterile rubber gloves, and the territory immediately surrounding is covered with sterile towels. In scouring the abdomen the piece of gauze used should be large enough to fill the hand—a square yard of gauze well crimped, yields about the requisite bulk to make its handling convenient. Small bits of gauze or cotton held between a few fingers, cannot be considered in earnest attempts to render a large surface clean. For the application of alcohol and the subsequent drying, two small pieces of gauze each about half a yard square will do. In all, no less than four pieces of crimped gauze—two large and two smaller ones—should constitute the content of this parcel, when the soap and water routine is followed.

The use of aseptic gauze in place of the antiseptic, for wound dressings, simple and plausible as it may seem, is nevertheless the outcome of a complicated evolution. This demonstrates again, what has been the case with many of the fundamental conceptions in the practice of surgery, which at the present time, after their unencumbered exposition by our teachers, appear almost self-evident.

For wound dressing, aseptic gauze, dry and porous, is the best material. Indeed, many clean wounds would not have to be dressed at all, were it not for fear of an injury to the delicate suture-line, or the risk of contamination from without, before it has had time to become naturally sealed by the healing process. Even after the most painstaking apposition, occasionally there may be slight

oozing from the line of the incision; but the gauze dressing serves to take up the secretion at once, and keeps the wound dry, while, at the same time, it admits of sufficient ventilation to keep the covered skin in a healthful state. To secure the maximum aeration, the piece of gauze which is in direct contact with the wound, should always be a crimped piece. Four to eight such pieces, each half a yard square, may be applied, depending on the case. The bulkier dressings are sometimes used as elastic pads, to prevent the accumulation of serum or blood where this is anticipated. A square of uncrimped gauze or a folded towel may be chosen as a cover, but never, impermeable material, such as rubber tissue, except where there is a special indication, as for example, where there is danger of soiling the dressing from without, by dejecta or urine. It can be readily illustrated in the laboratory, how the mere drying process inhibits the development of a colony of bacteria. That warmth and moisture, on the other hand, are vital to bacterial growth, is a surgical platitude. Normally an invisible evaporation takes place from the dressing, and the surface is thereby cooled. An enclosure, impermeable to moisture, causes the atmosphere in the dressing to stagnate, and the secretions to decompose, and provides the conditions necessary for the rapid incubation of germ-life.

The Dry Aseptic Dressing

This analysis of the sterile wash and gauze needed at an operation, is given in considerable detail, in order to facilitate a clear understanding in this matter, between the surgeon and the nurse. Precision in such things as these, is the basis of a reliable operating-room service.

The nurse's list of supplies for one laparotomy:

Nurse's List of Supplies for One Laparotomy

3 to 6 head covers, and gowns, for doctors and nurses.

7 to 9 pairs of rubber gloves, and 2 to 4 pairs of half-gloves.

1 laparotomy sheet.

2 dozen towels.

2 covers for the supply-table.

½ gross of gauze sponges.

2 dozen gauze tampons.

1 dozen abdominal pads.

1 parcel scrubbing gauze.

1 parcel dressing gauze.

To a certain degree, the operating-room nurse may exercise her natural inventiveness, in the get-up of this stock of supplies for an operation; but she should never allow variety in design to impair the utility of an innovation. In general, in the pursuit of asepsis, it is not complexity and multiplicity, *but simplicity and uniformity, that are most desirable.*

CHAPTER IV

The Sterilization of Utensils and Instruments for Operation

It has long ago been determined that sterilization by boiling, is far more reliable than sterilization by disinfection, and the practice of attempting to render operating-room utensils aseptic by other means has largely been abolished. Every well equipped operating-room should have a separate *utensil sterilizer.* It should not be a small model, but of such dimensions that, without exception, every article in the operating theatre which directly or indirectly might come in contact with sterile solutions, materials or instruments, or the gloved hands of the surgeon, has room in it. This includes all containers and receptacles intended for use at the operation, basins or tanks for sterile solutions, trays for materials and instruments, and also the plates of the operating and supply tables. Glass is heavy, easily chipped and fragile. Agate ware, though less attractive, is much more serviceable. The customary glass panels on operating tables are easily dislodged and broken, and could well be replaced by plates of agate or enameled ware which are not laid into a framework like panels but *cover* the underlying supports, and can be removed and rendered absolutely sterile by boiling. Similarly, there might be substituted in place of the glass top of the supply table, a plate of the same ware consisting of a number of smaller segments with shallow interlocking grooves, so that they can be

The Utensil Sterilizer

folded upon each other, or detached, and put into the sterilizer.

Under the heading of operating-room utensils are comprehended:

Operating Room Utensils

1. Containers for sterile solutions.
2. Utensils required during the scrubbing of the patient, and for irrigation.
3. Receptacles for waste materials, and bacterial discharges.

Provision for Cleansing the Hands

In the modern operating-room, where ample provision is made for the mechanical cleansing of the hands and arms with sterile soft soap, sterile brushes and warm, sterilized running water from a conveniently situated tap, the numerous basins with solutions for the hands become superfluous. All that is necessary in their place, is one sterile basin containing about a dozen sterile gauze sponges saturated with strong alcohol. The alcohol is needed to locate small wounds, to remove the residual moisture and close the relaxed pores, after the scrubbing and drying of the hands and arms has been attended to with due care.

On each side of the operating table, within easy reach, there should be a basin of sterile water in which the gloves may be rinsed during the operation. A third basin is reserved for the nurse at the supply table.

In general, the same principles that are followed in preparing the hands for operation, also can hold good in rendering the field of operation surgically clean. The soap and water routine may be exactly the same except that here gauze is preferred by many to the harsher brush. Consequently the accessories are also few in number. Warm sterile

water from an *irrigator* takes the place of running water. After drying, a little strong alcohol is allowed to complete the dehydration of the surface. For this another *small sterile basin* with a few gauze sponges soaked in alcohol, is kept in readiness by the nurse.

The Irrigator

The irrigator apparatus referred to, consists of two reservoirs or tanks of agate ware each holding not less than a gallon of fluid. Connected with each of these, is a rubber tube at the end of which is a slender metal cannula or nozzle with a stop-cock, to regulate and control the flow. The tanks are suspended from a stand on which they can be easily raised to increase the hydrostatic pressure, or lowered for the convenience of the nurse in refilling or detaching. The refilling of the tank is simple, and can be done best by means of a *sterile pitcher*. The sterilization of the tanks, tubes and nozzles, is accomplished before the operation; both irrigating apparatuses are disconnected from the stand, and boiled together with the other utensils. Pending their use, the attached nozzles may be safely lodged in the tanks to which they belong, submerged in the irrigating solution. Sterile water fills the one, the other contains the solution indicated by the surgeon, for example, tannic acid or zinc sulphate, which are to act as astringents to facilitate grasping the mucous membrane in a vaginal plastic, acetone, for bathing a cancerous cervix, or, it may be reserved for physiological saline, for intravenous infusion, or plain sterile water for hypodermoclysis or rectal feeding during operation.

Large quantities of fluid, above all, if they are known to be septic, should always be evacuated into a *deep* vessel, to prevent undue splashing; the ordi-

nary *pail* of agate ware, advantageously supplied with a wide, grooved nose-piece to facilitate emptying, is the best utensil for this purpose. Two such pails, one placed on each side of the operating table, are convenient for collecting the waste materials, and serve to remind the surgeon and his assistants that soiled sponges and gauze should not be scattered promiscuously about the floor of the operating room.

Provision for Septic Fluids

The bean-shaped *pus-basin* has retained its place as a useful article, because its form makes it peculiarly adaptable to the varying curves of the body. The *pus-pan,* really a modified bed-pan, which can easily be pushed under the patient, and upon which any part of the body can rest without much discomfort, is designed especially to catch the pus and prevent avoidable soiling of the patient and the operating table. Its chief use, however, is in office and dispensary surgery, as when an abscess has to be opened in a location where the pus-basin is not practicable.

Nurses list of articles to be boiled in the utensil sterilizer:

Nurse's List of Articles to be Boiled

1. The folding top of the operating and the supply tables.
2. Two small alcohol basins.
3. Six basins for sterile water.
4. Two large irrigating cans with tubes and nozzles.
5. Two pitchers.
6. Two pus-basins.
7. Three pails.

While the sterilization of operating-room *utensils* by boiling in alkaline water, and their adaptation to

this by the manufacturers, is, strange as it may seem, of comparatively recent date, the routine sterilization of the *surgeon's instruments* by this method, and the elimination of ornate hefts and designs which were difficult to keep clean, marks the time when aseptic surgery really began. The sterilization of instruments by boiling is so easily accomplished, that it required but little more than the proof of its unequalled reliability to win for it a permanent endorsement.

The Surgeon's Instruments

Boiling water is all that is needed. Almost any container can be used as a sterilizer; its shape and construction are only of secondary importance. The water is made slightly alkaline, to prevent the rusting of the metal. For this end, caustic soda, that is, sodium hydroxide (NaOH), which can be obtained everywhere in the form of sticks containing about 90 per cent. of the water-free sodium hydroxide, is to be preferred. It is practically odorless, and very convenient to handle. To a thousand parts of water, one part of sodium hydroxide will generally suffice. Certainly, in exceptional instances, as in the case of rain-water which contains much organic matter and carbonic acid, or is contaminated with sulphur, as in some districts where soft coal is burned, as much as ten parts to the thousand—1 per cent.—may have to be allowed. Nothing is gained usually by increasing the alkalinity beyond the point necessary to prevent oxidation of the instruments. On the other hand, rubber goods, bags, tubing—in the event that this should be advantageous—may be boiled along with the instruments with comparative impunity, if the solution is not too strongly alkaline; but very caustic solutions would soon destroy them.

The Method of Sterilizing Instruments

The *time* required to render instruments unquestionably aseptic, varies with the nature of the contaminating organisms. Some of the ordinary pyogenic bacteria possess but little resistance and succumb quickly to the action of alkaline water at the boiling temperature. Five minutes may suffice to make these inert. It is the *spore-bearing* bacilli chiefly, which complicate the problem of sterilization. The average time it takes to destroy most of these has been experimentally fixed. A representative member of the group is the tetanus bacillus, Not only do its spores possess the characteristic resistance to a pronounced degree, but besides, they are developed rather rapidly, that is, at body temperature, often within twenty hours. From the behavior of these spores when subjected to the destructive action of thermic agents, the average time necessary for reliable sterilization in general, can be deduced. Reasoning on this basis, it may be said, that if a germ-laden instrument is boiled in alkalinized water for fifteen minutes, its sterility is insured with reference to all the organisms which are commonly responsible for a wound infection. It scarcely needs to be added that this presupposes that the water is boiling actively during the entire specified time, that the instruments are all completely submerged, and that the sterilizer is covered, to prevent undue lowering of the surface temperature of the boiling water.

The Time Required

Where resterilization is regularly practiced, as it should be, an additional, although strictly speaking, as far as the survival of spores is concerned, ordinarily a negligible safeguard is provided. Thus routine resterilization is advocated as a prophylactic measure to meet the demand of the exceptional,

not of the usual case. An instrument that has recently been in contact with a case which is known to have developed a tetanus infection, is not used after a single sterilization of fifteen minutes because it is chiefly for these spore-bearing bacilli that resterilization may be of value. If such an instrument cannot be temporarily dispensed with, on account of some unalterable emergency, the only alternative to supplant in a way, although imperfectly, the peculiar action of resterilization after a day's interval, would be, to double the length of the boiling time. In this connection it is also noteworthy that the spores of the tetanus bacillus are but slightly affected by the *drying* process which is otherwise so inimical to bacterial life. It is possible, for example, that an instrument may convey living tetanus spores to a wound, two years after its contamination. This view of the persistence of tetanus spore life, is also tenable in the case of the dust of the operating room where the unfortunate patient has been treated.

Object of Resterilization

The fact, that almost any kind of receptacle can fulfil the function of a sterilizer for surgical instruments, is of especial moment, when emergency surgery has to be done where proper facilities are wanting. But even in hospital practice, the most serviceable instrument-sterilizers are of relatively simple construction. A useful device consists of a lever which is connected with a pedal at the base of the stand on which the sterilizer rests. If the pedal is depressed with the foot, the tray is lifted out of the sterilizer-tank. This allows the boiling water to drain off, and the instruments to become dry, while the temperature falls sufficiently to permit handling and arranging them on the supply table.

The Instrument Sterilizer

Sterilizing Cutting Instruments

While there is unanimity of opinion as to the proper sterilization of metallic instruments in general, in the case of *cutting* instruments, particularly scalpels, some surgeons have allowed a dangerous latitude. Surely it *cannot* be correct to be more lenient with the sterilization of a scalpel than with other instruments. Of all instruments it is the one that comes into the most intimate contact with the wound while inflicting it, and its absolute sterility must be beyond question. The only reason for this deviation, seems to be the fear of impairing materially the acumen of the cutting edge, when the knife is subjected to the boiling process. The question might as well be asked, whether a dull blade should be preferred to a sharp one, obtained at the risk of an imperfect asepsis. With the clear understanding that the safety of the patient who submits to an operation at the surgeon's hands, is largely dependent upon the asepsis which is practiced, and the asepsis in turn, on the sterility of the instruments, there can be no hesitation about the answer. Besides, although it is undoubted, that the blade can be noticeably damaged by or during the boiling, the impairment must not be great, if proper precautions are observed. Firstly, all scalpels ought to be boiled encased in a small knife-tray, which, while allowing water to have free access, prevents the jostling of instruments against their sharp edges during the process of ebullition. Secondly, the cutting instruments may be chilled, by submerging them in cold alcohol immediately upon their removal from the sterilizer.

Finally, it ought to be an inflexible rule of surgical cleanliness, that no instrument which has been used at an operation, whether the case is known to

The Instrument Closet

be an unclean one or not, shall be returned to the instrument-closet without the proper cleaning and sterilization. At the same time, damaged instruments are laid aside for repair, cutting instruments which have lost their keen edge must be sharpened, and new suture materials supplied to replenish the deficit in the stock. Order should be cherished here, as in many things pertaining to the practice of surgery, not only by the nurse who has charge of the operating-room or office, but by the surgeon himself as well, preëminently so, if he makes it a practice to operate in private institutions or homes or in the country, and must occasionally rely entirely upon his own equipment.

CHAPTER V

The Surgeon's Hands

One of the lessons which most of us have learned in our schoolwork in applied bacteriology, is that the hands are generally not aseptic. It requires a very thorough and systematic procedure to make them clean. After the ordinary washing it is usually possible to obtain a culture of germs from the fingernails, or interdigital folds. In rendering the hands surgically clean these places, therefore, are given particular attention. Notwithstanding this, bacteriological experience shows that sometimes growths may be obtained from as much as five per cent. of the cases, when the hands of all concerned in the operation are tested. The reasons are, on the one hand, that bacteria may penetrate the deeper layers of the epidermis where they become quite inaccessible to the cleansing measures, and the difficulty is enhanced when the frequent use of antiseptics has made the skin fissured and rough. On the other hand, the secretions of the skin itself are not always sterile. The procedure that is found to be practicable for the skin of the patient, is not equally well adapted for the surgeon's hands. Here the timely application of a penetrating and efficient disinfectant such as iodine, in order to reach the deeper strata of the epidermis, is not feasible. In these considerations are given the reasons for the evolution of the idea of covering the hands with thin gloves of India rubber and, at the present time, the wearing of well-fitting gloves, seamless, elastic,

Reasons for Wearing Rubber Gloves

impermeable to secretions, is thought to be the only practical and reliable safeguard against the possible transmission of infection.

Preparing the Hands for Operation

After the preliminary trimming of the finger-nails by means of the curved nail-scissors, the hands and arms are scrubbed with soft soap in warm sterile running water. Soft brushes, which have been sterilized by boiling, are best suited for the purpose. The only practical rule that can be given, is to scrub in orderly succession, every fold and crevice and every part of the hand, forearm and elbow. It is well to proceed as if each finger were a definite geometrical figure, a parallelopiped, presenting a volar, dorsal, lateral and mesial surface, and finally, a distal end, all of which must receive attention. If the brush is deftly used, the orange-wood stick can be dispensed with for the nails. In going from one finger to the next, the interdigital folds and spaces are attacked, both from the volar and from the dorsal side of the hand. The object of the warm soap-suds is to soften the superficial, germ-laden layers of the epidermis, and facilitate their mechanical removal. The bacterial debris, as it is set free, is rinsed away. No time can be fixed for this manoeuvre. Some manipulate more dexterously than others, but it is hardly wise to reduce the time to less than two minutes for each hand. The flushing with warm sterile water continues until all the soap has disappeared. The hands and arms are then rubbed dry by means of a rough sterile towel; sponged with strong alcohol for one minute and dried thoroughly. After this preparation, and without interpolation of the usual germicidal solutions, the hands are ready for the rubber gloves.

Dressing Rotation

In the customary rotation in dressing for an operation, the cap and mouth-binder are donned first. After getting the hands surgically clean in the manner outlined, the arms are slipped through the long-sleeved sterile gown. Finally the sterile rubber gloves are put on, and their cuffs drawn up over the ends of the sleeves, so that no part of the operator's forearm remains exposed. It would be manifestly inconsistent to allow the bare *forearm* to come in contact with the instruments, sterilized gauze, or the wound itself, while the *hands* have been so carefully protected.

Wet or Dry Gloves?

The gloves may be worn wet or dry. They are wet or moist after sterilization by boiling, and tend to adhere to the hand, so that it is not always easy to put them on in the correct way; that is, by grasping only the cuffed, reverted end while drawing them over the hand, and thus avoiding any contact of the bare fingers with the exterior surface. An expedient sometimes resorted to, which facilitates the slipping of the glove, is to fill it with sterile water. From the point of view of asepsis, this method is faulty. Firstly, some or all of the water, after bathing the hand, returns to the basin containing the other glove. Secondly, in pulling the glove over the end of the long sleeve of the operating gown, the latter is likely to be drenched, and diffusion at once takes place between the skin of the forearm and the surface. For the use at operations, it is an advantage to have gloves which are dry after the sterilization. Therefore, whenever there is an apparatus available for sterilizing by steam under pressure, the gloves are subjected to this process, preparatory to operation. With circulating-steam under fifteen pounds pressure at a temperature of 250° F. (121°

C.), thirty to forty-five minutes are sufficient. Each pair of gloves is sterilized in a cloth holder on which the size is marked. When the gloves are wanted, the folder is opened like a book; and, in a pocket on each side, is contained a glove with the cuff turned back, dry and well powdered, so that it can readily be slipped over the hand. The gloves which are used at operations go through a definite cycle. They are rinsed in hot soap suds and then boiled for twenty to thirty minutes in plain water without the addition of any chemical. This is done in order to destroy, at once, all the bacteria which may adhere to the glove, and to prevent their dissemination. A point worth remembering in reference to the effectual sterilization of rubber gloves by boiling, is to insert a large drain of gauze into each glove so that it will not collapse, and free access of the boiling water to its interior is not prevented. Good rubber resists sterilization by boiling in plain water numberless times before it becomes brittle and inelastic; but with alkaline solutions it deteriorates more rapidly. When the gloves have been boiled, they should be thoroughly dried between towels, and powdered with talcum before they are put away. These gloves are not only sterilized after they have been soiled, but again when they are used; the second time, preliminary to operation, preferably as indicated, by steam under pressure. In this way, germinating spores would also be destroyed, which before their germination might have resisted even the boiling process.

Preparation of Rubber Gloves for Operation

The fact that it is always a difficult matter to sterilize the skin after it has been soiled, should impress forcibly the importance of avoiding all unnecessary contamination. Fortunately, the bacteria

which most commonly are found to inhabit the skin, are not very pathogenic. So also streptococci picked up with the dust of the floor of the operating-room, are not apt to be as virulent, as those which come directly from a case recently infected. It is well known that repeated inoculations, as a rule, increase the virulence, while the drying process which takes place when bacteria are disseminated with the dust, tends to destroy them. Particular care should be exercised by the surgeon at all times, *to avoid direct contact of the bare hands with pus and bacterial discharges.* Laxity in observing this vital precaution, notably in dispensary practice, may lead to the most disastrous result. Here, highly infectious pus is evacuated from abscesses and phlegmons, and soiling of the hands is inevitable, unless they are protected by means of rubber gloves.

Contact of the Surgeon's Hands with Pus

The surgeon who considers it his duty to ensure an uncomplicated recovery for his patient, should be mindful of the channels or sources from which an infection could be transmitted. Besides the surgical polyclinic or dispensary, the dressing of unclean cases in the wards of the hospital, and in one's private service, has to be considered. The practice of examining gynecological cases vaginally without rubber gloves, is obsolete. Again, while research work on animals, and in the bacteriological laboratory, is sometimes of great importance in bringing about the solution of practical problems, it undoubtedly increases the risk of conveying pathogenic organisms to the operating-room.

Sources of Wound Infection

Because he comes in such close touch with the operating field, it is preëminently the surgeon himself who should keep his body clean and free from pus foci. If he should be afflicted with a furuncle,

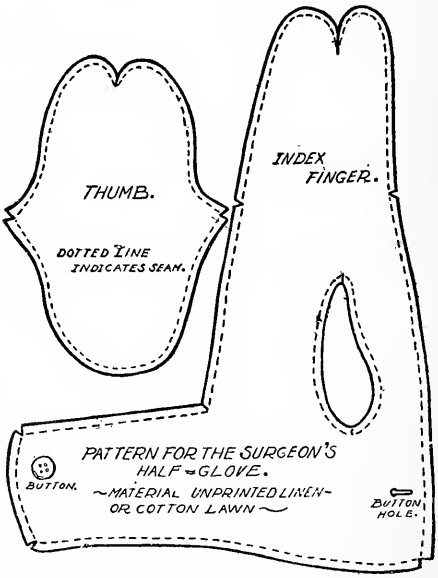
for instance, he should exercise additional precautions to guard his asepsis. A gauze-binder or mask which covers the operator's mouth and nose is *advisable* in every celiotomy or synoviotomy, and *imperative* in cases where an active rhinitis or tonsillitis exists. It is undoubtedly better to shave the face, or at least the chin; a beard, in general, is a dangerous ornament, but if it cannot be sacrificed, it should, by all means, come within the grasp of the mouth-binder and be well covered. Drops of sweat, too, that run down the face and reach the wound, may contaminate it, and give rise to an infection. If the hair of the head remains uncovered, detached hairs laden with germs may fall upon the operating field. A towel bound about the forehead and hair, or a snugly fitting cap, serves a two-fold purpose: it encloses the hair and absorbs the perspiration from the brow.

Personal Asepsis

By observing the well founded rules for obtaining strict asepsis at operations, the only factor that remains uncertain, as far as extrinsic infection is concerned, is the skin of the patient. However, if the surgeon and his assistants and nurses do not wear rubber gloves, the skin of all these, just as well as the skin of the patient, becomes a source of danger. Without rubber gloves it is quite impossible for the surgeon to guarantee the asepsis of his own hands, much less that of the many others that help him. It is true, that the use of bare hands often simplifies the technic, especially in gastro-intestinal operations, and as a matter of fact, some of the most skillful technicians work without gloves. The reason given, is that the slippery glove does not permit the ready grasping and handling of the delicate viscera. Rubber gloves have been manufactured with

Objections to the Rubber Glove

a pappilated or corrugated surface or with a silk-finish, but these do not correct the disadvantage. To slip the ordinary cotton glove over the rubber one is tedious, and makes the fingers too bulky. Cots of thin material can be used as covers for the index finger and thumb of the rubber glove at any time during an operation, but unless they are fas-



tened or anchored to the wrist in some way, these are readily dislodged during the manipulation, and may be lost in the wound.

The Half-glove

I have therefore adopted a *half-glove,* which is made of very thin unprinted linen—or cotton—lawn. (See figure.)

It fits the index finger and thumb snugly and a single button fastens it about the wrist. Unlike the

patterns followed in making leather gloves, both fingers and thumb have but a single slender seam so as to secure the least possible interference with palpation. If the button at the wrist is large enough, it can be easily buttoned or unbuttoned without any assistance, and the half-glove can be quickly donned or removed. Of course, it must fit the hand accurately. If the fingers are too long the tips will double upon themselves. The linen-lawn of which it is made, whether it is wet or dry, slips readily over the smooth surface of the rubber glove. A supply of half-gloves may be boiled together with the instruments and suture material, and put on wet, if the usual sterilization with steam under pressure is not convenient. To those who have become accustomed to work with it, the half-glove can be distinctly useful in vaginal plastics or whenever blunt stripping with the finger is necessary, as well as in grasping and fixing the structures during vaginal celiotomy, femoral, inguinal, ventral herniæ and operations on the stomach and bowel. The half-glove is meant to be worn only as occasion demands it. In an exploratory laparotomy, for example, while searching among the intestinal coils and diaphragmatic or pelvic organs for a tumor, the half-glove would be a hindrance, while the smooth *uncovered* rubber glove enables gentle and almost frictionless handling.

Rubber Gloves are Indispensable

Notwithstanding a dissenting opinion which is occasionally expressed, the great value of rubber gloves in preserving a rigid asepsis cannot be denied. Even a glove with a few tiny perforations caused by a needle or a sharp retractor and escaping notice, is far better than no glove at all. Furthermore, if the tear is not very minute it is seen at

once, and it is a simple thing to change the damaged pair. A rubber glove of good quality, if it is not too large, but fits the hand properly, will stand considerable wear. The tactile sense is impaired somewhat, it is true, but surely never to such an extent that it makes the difference worthy of consideration.

Training in Asepsis

In short, the surgeon is constantly living in a dilemma. He, more than others, is subjected to the opportunities for contaminating his hands with virulent germs; he, more than others, should keep his hands unpolluted by pus. Not merely on the *theoretical understanding* alone, of these principles, but upon their *constant application,* depends the good which results. The aseptic manner of handling diseased conditions must have become an integral part of the man.

CHAPTER VI

Wound-Healing and Scar-Formation

It was Rudolph Virchow who, in his work, "Die Cellularpathologie," first gave a scientific exposition of the theory that every cell in the human body comes from one original cell, and elucidated by his striking logic, the manifold significance of this assumption. After the initial stimulus has been given to the ovum by fertilization, a progressive cell-division by mitosis is inaugurated, which follows an invariable law. But the new-formed cells have not all identical characteristics. In the cycle of cell-evolution, one of the primitive functions may become highly developed; other functions, which were originally common to all, but not called upon by the demands of the organism to be duly exercised, eventually undergo a decadence, or are entirely lost.

Developing and Declining Cell Functions

So it is, for instance, that in some of the cells with pronounced *secretory function,* the *function of reproduction* may be wholly wanting. If that part of an organ which consists of such cells is subjected to an injury, the damaged part cannot be repaired directly by cell-division of the remaining secretory cells. A makeshift repair occurs instead, in which tissue cells which still possess the power of cell division, proliferate. By encroaching upon the defect, they give rise to a bond of dissimilar tissue which constitutes the *scar.* Thus, in a healing wound of the kidney, not the secretory portion, but the stroma, contains the most actively growing constituents. Cell-division is vigorous among the cells of the connective tissue and the endothelium of the capillaries, while the wounded parenchyma shows

Specialization and Loss of Reproductive Power

very little tendency to regenerate itself. In any single type of tissue moreover, for example, glandular epithelium, it is not the older cells, mature in their particular function, in which active cell multiplication must be looked for; but rather, the younger forms, which are still immature, and not highly differentiated.

Specialization and Cell Growth

But while advanced specialization in cells often implies a diminished reproductive activity, it does not follow that they have also lost their inherent power of *increasing in size* by growth. In fact, when the nutritional facilities of the environment are adequate, such cells may undergo an hypertrophy which is more or less commensurate with the increased amount of work imposed upon them by the new conditions. Indeed, it is the rule, that they become equal to a greater demand upon their special function by an increase in size—a truly compensating hypertrophy—rather than by cell multiplication—hyperplasia. If, in these cases, hyperplasia were in accordance with the natural law, there would result a number of immature daughter-cells, which only after a certain degree of development has been reached, are capable of performing the elaborate function of the cells from which they were derived. Initially they would be of little immediate worth in truly compensating for a functional loss. The direct hypertrophy of highly specialized parenchyma cells therefore becomes necessary after an injury, because a part of the organ which is still sound, must help to do the work of the whole. Hypertrophy of the parenchyma cells may occur simultaneously with the wound healing process, but has no direct relation to the formation of the scar itself.

Even when the coaptation obtained in a surgical wound of the parenchyma is relatively satisfactory, many cells which have perished as a result of the trauma must be removed during the healing, and new cells take their place. The new tissue is not the same as the old, and cannot replace it in function. It consists largely of those tissues in the wound area which engender the greatest reproductive activity, *irrespective of their functional adaptation.* It is not the fittest, but the most rapidly proliferating elements, that close the defect. There appears a complex bridge-work consisting mainly of connective tissue. Its function is preëminently a mechanical one, and from the point of view of secretory or excretory activity, the cells reveal little more than a primitive character. The same law obtaining, the young scar tissue of a healed internal organ, resembles in the chief points histologically the scar tissue found in recently healed wounds of the surface of the body. Some of the parenchyma cells which are peculiar to a viscus may be incorporated in the scar, and help to indicate its genesis. In the course of months or a year, however, it consists of little else than the ubiquitous fibrous connective tissue, in the contracting mass of which the existing vessels have become obliterated, and the parenchyma cells have disappeared.

Wound Healing is Imperfect

The reaction which takes place in the healing of an aseptic wound of the viscera, is comparable to that which takes place in other wounds—the differences are incidental rather than fundamental, and depend on the peculiarities and the specialization of the tissues involved. In practice, there is hardly a wound inflicted by the surgeon, which does not also

Role of Connective Tissue in Wound Healing

affect the selfsame connective tissue, on account of its universal distribution in the animal organism as a supporting substrat or sheath for more highly organized and more vulnerable structures. Notwithstanding its predominating rôle in almost every process of wound-healing, it is of some surgical importance, also to have a clear insight into the relative regenerative power displayed by other typical tissue groups.

Other Tissues in Wound Healing

In this study it is at once apparent, that besides the various closely allied types of connective tissue and the endothelium of the capillary blood vessels, there is also the epithelium in general, excepting that which is highly differentiated in function, as in the secretory portions of the various glands, that is to a greater or lesser degree capable of cell-multiplication by mitosis. Hand in hand with the connective tissue, this too plays its part, although but a minor one, in tissue repair.

Likewise, to a limited extent, the striated muscle may produce from the sarcolemma nuclei, new striated tissue elements. In the cell of smooth muscle, and above all, in the nerve cells, however, the generative function seems completely abolished. Moreover, cells that have reached the end of their developmental cycle, as for instance, the polymorphnuclear leucocytes, belong to the class which has not longer the power of reproduction.

Healing of Cartilage

Cartilage injured, or fractured, or divided in an operation, soon shows some tendency on the part of its characteristic elements to repair the lesion; still, it is not infrequently granulation tissue only, that fills in the interspace, and the result is then a purely fibrous scar. In the case of a fractured bone, signs of indirect cell-division become manifest as

early as the second day after injury, and the cells of the osteogenic layer beneath the periosteum, begin to proliferate in the vicinity of the fracture. The so-called external callus, which is often felt as a fusiform thickening, owes its origin conjointly to the lacerated, and subsequently proliferated connective tissue around the bone, as well as to the periosteum and the osteogenic layer itself. It is, so to speak, a natural splint, which shrinks markedly after firm union of the fractured ends has taken place. Bony tissue is replaced readily, and the hope may always be cherished that even a very large loss of substance will eventually be made good. If no soft parts become accidentally interposed and the periosteum is not destroyed, it is possible for an entire bone, for example, the clavicle, to regenerate itself. Strictly speaking, the regeneration of the bone is wrought, not by the periosteum which is nothing more than a limiting membrane of dense fibrous connective tissue, but by the layer of true bone-forming cells, the osteogenic layer, which is retained beneath it. In the surgical transplantation of bone the periosteum is not essential; it is the osteoblasts which are liberated from beneath the periosteum as well as from their bony casement, the Haversian canals, that have to do with the new-formation of bone.

Regeneration of Bone

As previously indicated, striated muscle has but a limited power of reproduction, and this, from the nuclei in the sarcolemma. The new striated elements resemble at first the immature striated muscle cells of the embryo. Their stability may not be great, they may undergo pressure atrophy and be replaced by connective tissue. In a wound of the abdomen, for instance, where striated muscle is

Restoration of Striated Muscle

divided, the repair is chiefly by fibrous tissue, a sort of *inscriptio tendinae* resulting, while the part played by the scanty, newly developed, muscle elements when they do appear, must in reality be a subsidiary one.

The lack of new development is still more pronounced in smooth or non-striated muscle, which is dependent entirely on the connective tissue for the equalization of any loss of substance. It is true that the smooth muscle may increase visibly in bulk, but this is not due to a multiplication of the muscle cells. Its basis is an actual hypertrophy within the individual muscle-cell. The fact that smooth muscle, even when nutritional conditions are very favorable, does not increase in bulk by hyperplasia, but by hypertrophy, is strikingly illustrated in the pregnant womb. Here the existing muscle cells may grow to be as much as eleven times as long and five times as broad as those in the non-pregnant womb, while their *number* is not increased.

Repair of Smooth Muscle

Heart-muscle, in this respect, may be said to occupy an intermediary position between the striated and smooth variety. Though it exhibits but little reproductive power, it seems probable, that the enlarged muscle in a hypertrophied heart is the result, not only of an increase in size, but also an increase in number of the individual muscle-cells. Nevertheless the recuperative power of the heart-muscle itself is not conspicuous in wound-healing; this is apparent in case of penetrating wounds of the heart, which heal with the formation of a fibrous scar.

Repair of Heart Muscle

If nerve-tissue of the cord or brain undergoes repair the connective tissue of the gray matter—the neuroglia—comes to the foreground. Moreover, dendrites or neurites which have been severed,

may regenerate as long as the ganglion cell to which they belong remains uninjured. Even the ganglion cell itself may undergo a reconstruction, as it were, if the cell-body has been but slightly damaged, providing the nucleus is still intact. The specialization of the cell, does not abolish its power to grow, and to undergo hypertrophy. It is only the power to multiply by mitosis, that is lost. In the case of the peripheral nerves, the restoration of continuity of an axis-cylinder is known to be possible, if the defect is not larger than five centimetres. At least, three to six months should be allowed for this process of repair. Larger defects will also heal, if tissue splints are placed along the path of the excised nerve between the cut ends.

Healing of Nerve Tissue

Irritating antiseptic solutions in contact with the peritoneum, provoke a defensive response in the surface endothelium, as well as in the connective tissue substratum. The outcome is an aseptic local peritonitis—a cellular peritonitis—which may result in firm adhesions between two contiguous peritoneal surfaces. Similarly, a gauze drain can cause adhesions of the peritoneal surfaces of the intestinal loops about it, so that a sort of conduit remains when the gauze is withdrawn. In other cases, as in lumbar or iliac colostomy wounds, it is to be seen that adhesions may form in less than twenty-four hours. In case of severe anemia, it appears that the formation of adhesions may be considerably delayed. It might thus happen that two peritoneal surfaces of bowel, which are held in contact by a Murphy button, may show no adhesion at all, even. after three days have elapsed. That a peritoneal coaptation may result in delayed union of a bowel-wound in low states of the system, is a point worth re-

Peritoneal Reaction to Irritation

membering in intestinal anastomosis where suture is not employed.

True gland-cells, that is, the cells which produce the secretion characteristic of a gland, are highly developed and do not reproduce their kind *directly* by cell-division of the mature cell. It is rather by cell-division of more primitive cells, and their subsequent metaplasia, that the destroyed gland-cells are replaced. In the case of the liver, Hess and Ribbert have demonstrated an exceptionally active proliferation of the parenchyma-cells after injury. The cellular connective tissue in the healing wound contains numerous newly formed bile-passages, and apparently the immature cells change into mature liver cells with their highly specialized function. But even with this unusual impulse, which is evinced initially towards complete restoration of the damaged part of an organ to its original functional worth, the architecture of the new parenchyma is atypical, and there is in the end, as the recent tissue grows older, a much greater proportion of fibrous tissue, in which perishing gland-cells are not replaced by new ones.

Healing of the Parenchyma of Secreting Organs

If the phenomena of healing are studied in a surface-wound, which has not been sutured, but is left agape to granulate, it will be seen that, under normal conditions, the surfaces are red and clean and covered with warty excrescences—healthy granulations. Within three hours following the injury, there is abundant multiplication of the nuclei of the connective tissue cells; and, after one or two days, mitotic division is apparent in the endothelial cells of the neighboring capillaries. Each granulation consists of sprouting capillaries, enveloped and supported in young connective tissue.

Open Wounds

When the balance between the two is disturbed, as when irritating substances bathe the wound, large, thin-walled capillaries, covered with a scanty protecting sheath of connective tissue, appear. These are the redundant, readily bleeding granulations, the *exuberant granulations* of a granulating wound.

Exhuberant Granulations

In the normal course of healing of wounds opening upon the mucous or cutaneous surfaces of the body, as the granulations fill the defect, the ingrowing epithelium covers the raw surface. In a wound of the skin, for instance, the advent of the epithelium can be followed by noting the position of the thin blue border at successive dressings. The new epithelial protective layer springs from the younger and more deeply situated cells of the epidermis, the cells of the Rete Malpighii. The older surface cells with cornifying protoplasm, and disintegrating nuclei, are at the culmination of their life-cycle, and no longer possess that power of multiplying by cell division. For this reason skin grafting is not apt to be as successful with the cells obtained by simply scraping the surface, as when a thin epidermal graft is taken close to the tops of the papillae by means of a sharp razor.

Epithelialization

From what has been pointed out, it is clear, that any production of scar tissue in excess of what is absolutely necessary for the mechanical purpose of holding the severed structures together, is undesirable *because in it is practically never reproduced the elaborate tissue of the parts which it unites.* In this connection, the question might arise, if the excessive scar-formation which sometimes follows the closure of an abdominal wound, is a prophylactic or predisposing factor in the occurrence of post-operative hernia. In the vertical

Massive Scars

median incision for celiotomy, the resultant scar is vertical. It has none of the elastic fibres, and none of the elasticity of Scarpa's fascia which it traverses, and offers a definite resistance to every excursion of the abdominal wall, interfering directly with its normal mechanics. When, at last, it yields to the strain, having no elasticity, it yields indefinitely, and the hernial protrusion so common after this incision, is imminent. An excessive scar is a hindrance rather than an advantage, and while the *quantity* of the abnormal tissue is increased, its *quality,* its elastic fibre content, is not improved.

Elastic Fibres

The fact that, in general, elastic fibre is but slowly and imperfectly regenerated in a cicatrix, merits due consideration in the surgery of the various structures of connective tissue origin. *Tendons,* which are rigid, inelastic connective tissue formations, and serve to anchor the contracting muscle, are comparatively devoid of elastic fibres, and their reconstruction after an injury is functionally more or less satisfactory. In the subcutaneous section of the tendo Achilles, a gap of two inches following the correction of a pes equino-varus, need ordinarily cause no solicitude. The healing of *fasciae* also, because they are of connective tissue origin, may be expected to take place rapidly; still, how well its functional worth will be restored in each case, really depends on how much elastic fibre originally enters into the make-up of the particular structure. Scar tissue has less stability than the fibrous tissue which appears in the body under normal physiological conditions. In addition, it is decidedly sluggish in developing elastic fibres in its matrix. Scarcely any can be detected before three weeks (Ziegler; Adami). They are to be found chiefly

in the periphery of the scar, and occur as very fine fibrils. It is clear therefore, that physically, scar tissue cannot at all supplant a fascial structure which is rich in elastic fibres. On the other hand, it may replace fascial defects more adequately when the fascia is inelastic, particularly when it is in an anatomic location where it is not subjected to any great strain. Again, *ligaments* which, as a rule, are inextensile bands of fibrous tissue, and serve the purpose of binding bones together, may become relatively inefficient, when they are divided in an operation, or accidentally torn. Although, they heal promptly with the formation of a seam of new fibrous tissue, this bond of union is of inferior quality and tensile strength.

Furthermore some ligaments, such as the ligamenta subflava, which connect the arches of the vertebrae with each other, consist almost exclusively of elastic tissue. Here the elasticity of the ligament, may be said to act as a substitute for muscular power. Similarly the inferior calcaneo-navicular ligament—the so-called "spring" ligament—which is the prime factor in maintaining the bony arch of the foot, and gives it its elasticity, owes this quality to a considerable amount of elastic fibres. The reason, therefore, for preserving such structures as these intact during operative measures, as well as their imperfect healing after injury, is apparent.

Exercise and the Rôle of Elastic Fibres

It is the rule, in the animal organism, that elastic fibres occur in abundance in those structures of connective tissue origin which are physiologically subject to exercise. Thus, the loose, yielding perimysium externum of a muscle, that is, the external connective tissue sheath of it, contains numerous elastic fibres; while the rigid tendon, which is also

a connective tissue derivative, is characterized by the absence of elastic elements. Again, while in the main, the fascial sheath of a muscle abounds in elastic fibres, the fascial planes to which the self-same muscle is attached, may show them to be but few and far between.

Histologically, normal fibrillar connective tissue practically always contains *some* elastic fibres, although the number may be very small. Appearing as extremely thin fibrils in the matrix they broaden with advancing growth. They may form a complex meshwork of fibres, or, as in the endocardium, for example, by their fusion there results a fenestrated elastic layer or membrane. It is only when the elastic fibres are present in *predominating quantity* over the connective tissue bundles, and the mechanics of the arrangement of the connective tissue strands allows it, that they can impart to it their physical property of elasticity.

Elastic Fibrils in the Skin

From another than the purely cosmetic point of view, incisions involving the *skin* and the resulting scar, are of interest to the surgeon. As far as this is possible, the incision is made along the line indicated by a natural fold. In this situation the fine scar of a healed wound, besides receding from view, is subjected to only occasional, but not to constant stretching, and the new tissue has ample time, in the intervals, to recontract and to regain its tone. On the abdomen vertical incisions, even after an almost scarless primary union, tend to widen gradually. Subsequently, as in all scars, the soft, pink vascularised tissue becomes white, hard and atrophic, and in the course of a few years, a scar which was at first faintly linear, may be a fourth to a half inch wide, and considerably attenuated.

Although the condition of the underlying structures may prevent, at this time, any actual hernial protrusion, the partial inefficiency of the repair cannot be questioned. Stretching occurs, no matter how nicely the skin has been closed, whether it be with Michel's clamps, or adhesive strips, or the finest cuticular or subcuticular suture. The real reason for an inadequacy in the healing of a cutaneous wound is, in all likelihood, to be found in the deficiency in elastic elements in its scar. It is to be recalled, that the normal skin is well supplied with these. From the subcutaneous connective tissue numerous thick elastic fibres radiate into the corium, and reduced in size terminate largely in a fine meshwork which lies just beneath the epidermis. If the limit of elasticity has been exceeded in the skin, numerous irregular, pinkish furrows appear on the surface, to indicate the lines along which the delicate corium has been overstretched and ruptured. Here, instead of the complex plexus of elastic fibres, isolated fibres that have remained intact, in small numbers, and running a parallel course, can be traced across the attenuated zone. Thus the undue distention of the abdominal wall in pregnancy, results in the appearance of the striae gravidarum in the integument. In old age, too, the skin loses its elasticity; a physiological degeneration of the elastic fibres, keeps pace with the other processes of involution incident upon senile atrophy.

Few Elastic Fibrils in Old Scars

Old scar tissue bleeds but little, or not at all, when incised, because its blood vessels have disappeared. It has but little vitality, and shows only slight resistance to the destructive action of pathogenic germs. Thus, it may happen that suppuration fol-

lows the line of a previously existing scar, to reach the surface, because the normal skin about it, with its elastic framework and vigorous cells, proves to be a very efficient barrier to its progress.

Should a Young Scar be Exercised?

The salient question, Does exercise help the development of elastic fibre in the scar following an operation? has not been finally answered. It is only when the scar is still recent, that it is soft and pliable, and possesses a small degree of resiliency. It is at this time, *if at all,* that the development of the elastic fibre must be encouraged by proper exercise of the part. Nevertheless, if the scar is put to a strain *before* it has time to acquire sufficient stability, it will yield and broaden by stretching. A laparotomy scar, one week after operation, is usually too young to sustain the weight which is brought to bear upon it during bodily movements. The average time required to obtain union which is sufficiently secure to allow the patient to be out of bed, is from twelve to fourteen days. During the week of lounging, which follows the stay at the hospital, or perhaps an additional week, a firm, correctly applied bandage may give support to the wound. If the hypothesis is tenable, that the regeneration of elastic fibre can be stimulated by *training* the scar, then the wearing of trusses or belts after operation is not logical, and graduated exercise ought to begin after the third week, that is, coincident with the time when the elastic fibrils begin to appear. However, this may be, there is a pretty general disinclination among surgeons to endorse the wearing of mechanical appliances, for long periods after an operation, except in the flabby patient who possesses but little physical tone.

CHAPTER VII

Aseptic Suture Material

There is a certain, inevitable scar-formation going on in every wound during the healing of it, no matter how nicely apposed the divided tissue may be. The cicatrization is materially increased by the presence of a foreign body, or the action of chemical irritants. All suture materials are foreign bodies, and all antiseptic solutions are chemical irritants. The exclusion of irritant solutions is a simple matter and is practicable, but not so the abolition of the suture.

Suture Materials are Foreign Bodies

In a *wound which involves only the surface,* a skin-wound for example, the actual penetration of the tissues, and the lodgment of sutures in them can frequently be avoided by the use of tiny clamps of metal, Michel's clamps, or sterile zinc oxide adhesive strips. It is thus possible, in a limited number of cases, to obviate altogether the introduction of a foreign material into the tissues. But, when the *deeper* layers of a wound must be brought into apposition, the use of the suture can scarcely be circumvented.

Sutures Avoidable in the Skin

Coaptation is needed, until the newly-formed tissue has sufficient stability to retain the severed parts in position. After that, solution of continuity and absorption of the suture by the tissues which it traverses, is looked for, unless the material is not absorbable, and must either continue to remain as a foreign body, or else be removed by extraction. But extraction of sutures from the deeper layers is

After Healing, the Sutures are Redundant

impracticable, and again, it is obviously objectionable to leave sutures that cannot be absorbed.

Qualities of Suture Material

A solution of the problem, was given long ago (1870), when it occurred to Sir Astley Cooper, that violin strings might also be used in surgery. Since then, the preparation of aseptic, absorbable sutures of catgut, has been the subject of considerable study. The prime qualities of suture material, as it is required in plastic surgery, are:

(*a*) Sterility.
(*b*) Definite and measured absorbability.
(*c*) Fineness with adequate tensile strength.
(*d*) Pliability.

Catgut, Histologically and Chemically

Even at the present day there is no vegetable fibre, animal or synthetic product, which answers all these requirements quite as well, as the suture prepared from catgut. Catgut, as its name does not imply, is usually obtained from sheep's gut. After the process of preparation, the serous, muscular, and mucous coats are lost, and there remains little more than the submucosa, consisting of a stratum of loose connective tissue with a few elastic fibres. In the main, then, the catgut of commerce consists of connective tissue. From the chemical standpoint, excluding the elastic fibres, almost its entire mass is collagen. Collagen is a substance which, with or without the aid of enzymes, furnished by polymorphnuclear leucocytes, and probably various other tissue cells, becomes hydrated, and is first converted into the water-soluble gelatin. In this form it yields more easily to enzymotic action, and undergoes further digestion, apparently resolving into albumoses and peptones, until it disappears completely and is absorbed.

Catgut Digestion

A piece of aseptic catgut imbedded in living tissue, calls forth a definite tissue reaction, which presents two phases. In the one, the cell activity is aimed at removing the foreign body which is lodged in the tissues; in the other, the forces at work are directed towards effecting a replacement of the damaged tissue in the path of the suture. But these two phases of cell-activity are revealed as well, in every healing wound. There, too, the destroyed tissue undergoes catalysis and is removed, while, at the same time, reconstructive processes are going on.

Tissue Reaction Towards Imbedded Catgut

The structural changes which take place in catgut when it is imbedded in living tissue, have been followed microscopically by animal experiments. With the imbibition of water from the tissue-plasma which bathes the suture, the piece of catgut begins to swell and untwist, and becomes loose in texture. The ameba-like polymorphnuclear leucocytes, which at the beginning are present in considerable numbers, find their way into the interstices of the suture, while the cells of the granulating tissue crowd closely around it. Under the influence of the moisture and the enzymotic action of these cells, the dissolution of the catgut fibre is started. At first there is, what might be called, a fragmentation of the catgut, and then a disappearance of the particles.

Microscopic Changes During Catgut Absorption

The inauguration of the whole process of catgut solution probably depends primarily on the absorption of tissue-water. By subjecting the gut to the action of certain chemical substances, the absorption of water can be retarded, and consequently its resistence to dissolution by the body tissues, considerably increased. Thus, catgut strands of more

Moisture Starts the Process

or less definite and known grades of resistance can be prepared.

Designating Catgut Resistance

To indicate the degree of resistance to absorption, it has been the custom of the manufacturers, with a few exceptions, to designate the suture material by the *number of days* it requires until pronounced signs of catgut dissolution are to be seen when it is imbedded experimentally in the thigh muscle of a rabbit. Thus, the term "forty-day" chromic catgut, for instance, is meant to imply that the particular strand has been treated with chromic acid to such a measure, that it is able to withstand absorption in the thigh muscle of the test animal for an average period of forty days. Thereafter, the rapidly disintegrating suture, can no longer properly be said to have any retentive value. With these facts in mind, the terms "10, 20, 30, 40, 60 or 80-day" catgut, ought not to be misleading; they have, in the human subject only a *relative,* not an absolute value.

Meaning of these Terms in the Human Subject

It is apparent, that the time required for absorption in the *human muscle* need not be exactly the same as that in the test animal. One's judgment as to how long a piece of catgut of given resistance shall last in the human tissue, depends on a number of factors which influence the rate of absorption. Besides considering the difference between human muscle and animal muscle, it must be remembered that not only *muscle,* but various other tissues are repaired by suture, and each tissue exerts its own peculiar catalytic action. The specific tissue influence upon catgut is still more detailed than this, for not only the different tissues in the same individual, but also the same tissue in different individuals, have this solvent power to a somewhat

unequal degree. In the case of a continuous suture of the skin, it can sometimes be observed that even the various portions of the same suture are not always absorbed with the same rapidity. In the semilunar hypogastric incision, a slight difference in absorbability may occasionally be discovered at the ends of the incision as compared with its middle portion which invades the zone of the suprapubic hair follicles. When segments of the suture remain exposed, as in skin and mucous membrane repair, the amount of surface moisture may have much to do with premature dissolution. Wet dressings, douches, discharges, wound or gland secretions, sweating, all may help to macerate the catgut, and shorten the period of its usefulness.

The *Useful Period* of Catgut in Human Tissue

Clinically, catgut behavior can most conveniently be studied in surface sutures. In order to eliminate outside factors which may complicate the observation, the wound must first of all, be kept dry. In the dry, clean wound the solution of continuity of the part of the suture which is imbedded in the tissue is indicated by the falling off of the knots on the surface. When this has happened, the continuity of the suture being broken, the material can no longer serve the purpose of holding the tissues together, and with this, its serviceability ends. Thus, it will be found, that a piece of fine "forty-day" chromic catgut may last five to seven days, and occasionally even twelve days or more, when employed as a skin suture. The variation in time required in similar locations may therefore be as much as one week. The same technic may have been resorted to in each instance, and still such marked latitude as this is observed for material of

apparently the same resistance. Obviously the reason is to be sought in the hitherto but little studied processes of tissue digestion. In the one case the enzymotic action unfolds itself more speedily, than in the other. This in turn is made possible by the presence of sufficient water in the tissue in which the suture lies imbedded. If there were, besides the living cells, no fluid in the intercellular spaces, no tissue-plasma, then the digestion of catgut in the tissues would seem quite impossible. Water is necessary for catgut digestion in the tissues, just as it is requisite in the digestive processes in the alimentary canal. In both cases the action is fundamentally one of progressive hydration. Water is taken up into the dissociating molecule of collagen, and finally assimilable proteoses and peptones result. So it is that catgut disappears more rapidly in the succulent derma of the young man, than in the desiccated skin of the aged.

Tissue Water Essential for Enzyme Action

It has been observed that in the course of catgut disintegration small fragments may be taken up into the bodies of the polymorphnuclear leucocytes. It would seem likely that the same principles are valid here in *intracellular* catgut digestion, that govern *extracellular* catgut digestion. The moisture supplied by the cytolymph, makes it possible for the enzyme produced within these cells to exert their solvent influence.

Extracellular and Intracellular Catgut Digestion

In a measure, the time of catgut absorption is also affected by the *thickness* of the strand. It necessarily takes longer to bring about solution of continuity in a thick, than it does in a fine suture. But the selection of bulky sutures is not in accord with the modern tendency towards finer technic. It is better to choose thin sutures, by which the most

accurate apposition with the smallest amount of damage to the tissues, is obtainable. Instead of *increasing the size* to obtain the desired durability, *the chromicization of the finer strands should be increased.* It is only in order to get sufficient *tensile strength* that larger sizes may be introduced, but never to increase the resistance. If the material is handled with the gentleness which the delicate make-up of the tissues demands, sutures which are coarser than No. 1 or No. 2 will seldom be required in the course of major operations. In other words, the finer sutures are to be generally preferred, notwithstanding that they may have to be chemically modified in order to become sufficiently lasting.

Choice of Thin Sutures

It is not tissue constriction and strangulation, but gentle tissue coaptation or apposition until the young scar is sufficiently formed to support the parts which it binds together, that is the end and aim of the reparative suture. The use, in many instances, of finer suture material than has been customary, will not appear an unnecessary refinement when besides the gross anatomy of the structures their *histology* is considered.

Thus, a fine catgut filament, 000 in size, or more accurately, 31-32 Brown & Sharp standard wire gauge, may well replace coarser material, for whipping the mesenteriolum over the invaginated stump of the appendix, for suture in all circumcisions of both male and female subjects, for primary coaptation sutures in the bladder, for repair of the ovary after partial excision, for skin stitching where removal of the suture is to be avoided, for buried sutures or mucous membrane sutures when required in dainty plastic operations on the face or elsewhere. Originally (1907), I had this catgut prepared for

Chromic Filament

me by the manufacturers (Van Horn) for ovarian suture, because fine-bodied needles such as are best fitted for this repair would not admit the coarser strands which are commonly in use. Indeed, after-bleeding from the stroma or hilum is less likely to occur with this technic, than when coarser material is used, because there is less laceration of the friable tissue. In its most generally useful form, 000 catgut ought to be chromicized to "forty-day" resistance. Occasionally, however, as in the mucous membrane of the nose or rectum, "sixty-day" chromicization is necessary. Filaments so fine as those represented by 000, it may be argued, require too much caution in handling, but this objection must grow weaker as the conviction grows stronger that the tensile strength is quite sufficient for the purpose for which it is intended—the coaptation and not the compression or constriction of the delicate living fabric which it mends.

Aseptic not Antiseptic Catgut

Chromicized, unlike iodized catgut, is so prepared that it contains no chromic acid which is not in stable chemical combination with its collagen. There is no free chromic acid or chromate in solution in the medium in which the strands are preserved. However, after a definite number of days, when the chromic catgut is converted into soluble bodies in the tissues, it is true that the chromic acid radical must again be liberated. But at this time, the more active healing processes are ended, and the traces of the foreign chemical no longer so readily disturb the chemistry of the young and susceptible growing cells.

In a general way, it may be said that for the usual purposes of suture, catgut of "forty-day" resistance should be employed. This *insures* stability

of the suture-line for a minimum period of about seven days, which is usually sufficient for wound healing. Only in certain localities, where the sutures are exposed to maceration from stagnating secretion, or when the structures are edematous as the perineum after childbirth, a bit of chromic catgut of "forty-day" resistance may undergo solution of continuity prematurely, that is, perhaps as early as the fifth day or even sooner after its insertion. Where this difficulty is anticipated, strands of "sixty" or even "eighty-day" resistance can be used, but this is rarely necessary. Where there exists doubt about the necessary resistance of a suture which involves the surface, it is better to choose inabsorbable material, such as silk-worm gut of the appropriate strength. When the suture involving the surface cannot be kept dry, silk-worm gut has many advantages over catgut. It is not only insoluble in discharge or secretion, but, unlike the collagen of catgut, offers no favorable medium for bacterial growth. Apposition can be maintained as long as even the most exceptional conditions may require, and when the union is secure, the silk-worm suture is easily extracted. When the stitch includes the skin, silk-worm gut is also preferable to silk or linen. Because of its lack of capillarity, it does not, as these do, imbibe bacterial fluids which bathe the surface, and conduct infection along the path of the stitch. There is ample scope to satisfy the various demands upon its tensile strength, from the coarser strands for a torn perineum, to the finest filament (XX Special, Van Horn), which is suitable for finer plastic surgery. It has the further advantage that it can be quickly sterilized by boiling in plain, or even in slightly alkalinized water.

Indications for Absorbable and Inabsorbable Sutures

Linen Thread for Hollow Organs

In the surgery of *hollow organs* such as the heart, blood vessels, stomach, bowel, bladder, where structures have to be repaired which are under constant or varying tension, it is unquestionably safer to adhere to the use of inabsorbable sutures in place of catgut, notwithstanding the fact that such sutures cannot be extracted and must remain as foreign bodies in the tissues which they unite. Such an inabsorbable thread also finds its place in the purse-string closure of the caecum after appendicectomy, or of the peritoneal sac of a hernia. Linen thread has the great advantage over silk that it can be boiled in plain as well as slightly alkalinized water with relative impunity, while silk more rapidly loses its tensile strength.

Objections to Catgut for Skin Repair

The cardinal objection to the employment of catgut suture on the surface of the body, is its great liability to become infected, and to transmit an infection along the stitch-canal to deeper planes. This will not appear startling, when it is recalled that the collagen content of the catgut suture easily becomes, in the presence of moisture, a good soil for bacterial growth. Silk or unimpregnated linen thread have the common disadvantage of capillarity, which also means imbibition of moisture, and conduction of germ-growth. Silk-worm gut has none of these properties, and is therefore a very satisfactory suture material for the skin. Even when a surface is naturally apt to be contaminated on account of the location of the wound, or where it is bathed in discharge, there is but little tendency to the development of stitch infection. Metal clamps, such as Michel's clamps, eliminate the trouble from stitch infection, because they make possible skin closure by clamping without perforation. They are

Silk and Linen

Silk-worm Gut

Skin Clamps

suitable in aseptic laparotomies; particularly in point, in the hairy zone of the pubes after the semilunar hypogastric incision. To avoid decubitus they should not be applied too firmly. Nevertheless, although correctly applied, they not infrequently occasion slight pain in the region of the wound. They should be removed after five days, a few strips of sterile adhesive plaster continuing to support the young scar for a few weeks. There need be no fear that the clamps will be dislodged by the patient, even if used on the abdomen to close incisions eight or more inches long.

Occasionally, as for instance, in some incised wounds of the face in children, in order to escape stitching, or after abdominal sections in place of skin clamps, sterile zinc oxide adhesive strips can be used. The secret of success in employing them, lies in the thorough removal of the fatty secretion. From a cosmetic standpoint the result obtained by either the clamp or the adhesive strip method, perhaps surpasses that obtainable by any suture method.

Coaptation with Adhesive Strips

In contradistinction to most other tissues, in the repair of osseous tissue, the physical conditions are such that absorbable suture is commonly inadequate. Only a few of the smaller bones may be an exception. When proper coaptation and fixation is not obtainable by reduction, traction, external splinting of a long bone, silver wire, Lane's plates, cortical or intramedullary splints of living bone, all may have their place.

Methods of Uniting Bone

At the present time, the most satisfactory way of supplying sterilized, plain, as well as chemically modified catgut, is in sealed glass tubes. Since it is in this case necessary to rely on the efficiency of

Guarantee of Catgut Sterility

the sterilization of the catgut by the manufacturers, many methods for its extemporaneous preparation have been suggested. While this tendency must appeal to one who is solicitous about the asepsis, and desirous to have under his control or supervision the sterilization of the catgut which he needs at his operations, it must be granted, on the other hand, that the usual complaint about catgut sterility is not well founded. For example, from the record of one series of 120 cases in which catgut, plain and chromic, from one of the firms in this city was used exclusively, in not a single instance was an infection traceable to this source. Most infections of the skin occur when a hairy territory is invaded, because it is so difficult to render it aseptic, and not because the catgut is at fault. If the catgut itself were responsible for the ordinary stitch infection, why is it that the skin and subjacent fascia, or the skin alone, and not the deeper strata of the sutured wound, are most usually involved? Why is it, that incisions in the hypogastrium near the pubes, or herniotomy incisions, are so prone to this complication, while when ordinary precaution is taken, incisions elsewhere on the abdomen, rarely show any redness or signs of local infection about the stitches?

Catgut is Dry Sterilized and Preserved in Sealed Tubes

If water were not incompatible with the catgut suture, the problem of catgut sterilization would be a comparatively simple one. As it is, sterilization by means of boiling water, or superheated steam is out of the question, and the process is usually one in which disinfection and dry sterilization in its various forms, are combined. A further difficulty presents itself in this that the medium in which the catgut is kept must be water-free, other-

wise the tube containing it cannot be boiled. Catgut, plain and chromic, thoroughly desiccated, is therefore put up in a medium consisting of chloroform and alcohol. The tube containing the strand of suture material is but half-filled with the liquid to allow for expansion, and can be boiled repeatedly to sterilize the surface without impairing the catgut. With this preparation, tubes containing kangaroo tendon can also be boiled, whereas if but a trace of water were present the suture would swell promptly and be converted into a rubber-like mass, having no value whatever as a suture. *The tubes are boiled, not so much in the hope of re-sterilizing their contents as to render their surface aseptic for the supply table.* This precaution is a vital one, because the surface of the tubes is apt to become coated with a fatty layer, and bacterial contamination is the result of handling. If they are simply immersed in antiseptic solutions, most of which in addition, as corrosive sublimate, are practically incapable of penetrating the fatty deposit, a germicidal action upon imbedded bacteria is doubtful indeed. If, however, the glass tubes are subjected to the boiling process in slightly alkalinized water (1-1000 NaOH), together with the instruments, absolute surface sterility is secured.

The Surface of the Tubes is Sterilized by Boiling

The question, What happens in the *interior* of the tube when it is boiled? is a natural one. In case the tube contains a mixture of chloroform and alcohol, which is absolutely water-free, and whatever may be the temperature to which this medium rises, when such a tube is boiled or placed in the steam sterilizer with the dressings, the only sterilizing effect which it can have on the contained

strand of suture material, is that which results from the action of *dry heat,* not wet heat; any trace of moisture due to water in the tube, would be utterly incompatible with the catgut. According to the manufacturers, a thermometer suspended in this chloroform mixture, within a sealed glass tube, indicates that the temperature of the mixture reaches approximately the temperature of the surrounding medium in the sterilizer. If this is correct, the additional sterilizing effect of this measure would be equivalent, in the one case, to that of a *dry sterilization* of from 10 to 25 minutes at about 100° C. (212° F.), and in the other, of a dry sterilization of not less than 35 minutes duration at about 121° C. (250° F.). That the sterilizing effect of this procedure can be but secondary in importance becomes clear when the degree of heat obtained, and the time are compared with that which is necessary to insure unquestionable sterility by *dry heat.* Thus dry sterilization would require about three hours at 140° C. (284° F.), or about two hours at 180° C. (356° F.). As long as no water is admitted, subjecting such tubes to the action of boiling water (100° C.), or steam under pressure (121° C.), does not impair the quality of the suture. It is only when the dry heat is carried considerably beyond this point, that charring results, and the material is destroyed. The only way, therefore, in which satisfactory sterilization of catgut can be obtained, without influencing the suture, is not by a single dry sterilization at very high temperature, but by *repeated sterilization at a lower degree of heat.* It is not on the effectiveness of a single, but of *repeated sterilization* that the sterility of surgical catgut really depends.

Effect of Boiling on the Catgut Strand Within the Tube

To a great extent therefore, the guarantee for the undoubted sterility of the animal suture used at operations has to be accepted from the laboratory which supplies it. It would be desirable to apply wet heat either by boiling or by means of steam under pressure to all suture material, but until an absorbable material which cannot be destroyed by hydration is found, extemporaneous sterilization by these methods, is out of the question.

CHAPTER VIII

The Anesthesia

It is not my purpose to enter into the details of the *technic* in the administration of anesthetics, only so far as this may be helpful in bringing about a better understanding and co-operation between the surgeon and his anesthetist. If the surgeon *alone* is to be held responsible for the safety of his patient, he cannot be indifferent to the methods of anesthesia employed, any more than he can disregard the asepsis which is practiced at the operation by his assistants and nurses. If the surgeon himself has had a thorough training in anesthetics—which is not as often the case as it should be—he is in a better position to work together effectually with his anesthetist; if he lacks this training, he may allow himself to interfere where this is not indicated, and, as far as the narcosis is concerned, may unwittingly put himself in the way of the proper management of the case. It is easy to understand, that pure chloroform, on account of its greater potency, becomes a dangerous narcotic in the hands of those who have not learned to use it correctly. The solicitude of the surgeon, upon whom perhaps an anesthetist of questionable experience has been thrust, is but natural. Indeed, there are legitimate reasons for attempts to displace chloroform by the less toxic ether, as a routine anesthetic. Nevertheless, thus far chloroform has not been displaced, because of certain disadvantages connected with the use of ether in every-

Relation Between Surgeon and Anesthetist

day practice. Its greater bulk and inflammability, the fact that its inhalation is more disagreeable to the patient, the relatively tedious induction of narcosis when it is used uncombined, the increased tendency to cause post-operative nausea and vomiting, all have militated against ether and have helped chloroform to retain its foothold, notwithstanding its toxicity. It is true that the induction can be shortened, and made more agreeable to the patient by preceding with nitrous-oxide gas, but the exigencies of every-day practice prohibit any cumbersome apparatus which cannot always be at hand.

Chloroform in Everyday Practice

It is for such reasons that attempts have repeatedly been made to combine the desirable properties of chloroform and ether, and to neutralize the objectionable ones, in the hope of obtaining an ideal anesthetic for general routine. One of the most useful of these anesthetic solutions is *anaesthol*—a molecular combination of chloroform (35.89%), ethyl chloride (17%), and ether (47.10%).

Essentially, its administration differs but little from the administration of pure chloroform. It is the chloroform content of anaesthol, and not the ether, that dominates the narcosis, although the depressant action of the chloroform is counteracted to some degree by the stimulant influence of the ether which constitutes almost one-half of its volume. The quantity of the anesthetic needed is relatively small—somewhat greater than when pure chloroform is used. The quantity required for an anethesia can be still further reduced when a quarter of a grain of morphine sulphate is given subcutaneously half an hour before the narcosis.

The Administration of Anaesthol

In an average case 15 to 20 cc. of anaesthol, given on a mask by the drop method, ought to suffice for the induction; not more than 40 to 60 cc. should be consumed during the entire narcosis lasting an hour or more.

From the patient's standpoint the anesthesia is, at times, a matter of considerable moment. It may be the recollection of the ill-effects of a former narcosis that deters her from consenting to a necessary measure. Again, the *odor* of the anesthetic may become markedly repugnant to those who have previously been under its influence, and assurance on this point may help to bring about a prompt decision. A few drops of a 10% emulsion of Persian oil of rose in deodorized alcohol on the mask, is an efficient way of eliminating this disagreeable element in the induction of anesthesia.

The Use of Oil of Rose to Disguise the Vapor

A little ether is kept in a separate drop bottle, so that during the narcosis with anaesthol its stimulating effect can be added when this is indicated —ether feeding. Or, the narcosis may be continued solely with ether by the drop method, immediately after the induction with anaesthol, should this appear advantageous. There is thus at command a morphine-anaesthol sequence, or, if one wishes, a morphine-anaesthol-ether sequence which is very flexible and readily adapts itself to the individual case. At the same time the technic which it entails is strikingly simple.

Ether Feeding

The chief danger with chloroform or its combinations lies in its action upon the circulation—cardiac collapse. From my own observations true cardiac collapse is very rare. Its frequency can be estimated to be about 2:2000, one-tenth of one per cent. of all cases which come to operation. Since

Cardiac Collapse

it is during the induction of the narcosis that this undue susceptibility usually becomes manifest, the importance of alertness and caution in inducing with chloroform or its combinations until the anesthetist has discovered how the patient responds to the narcotic, cannot be overestimated. In this connection the question is pertinent about the tolerance of the patient to former anesthetics. In impending collapse of the heart, there is increasing pallor and the pulse suddenly becomes diffuse and weak. If the induction has been gradual and the anesthetist attentive, these changes may be discovered in due time to avert disaster.

Abolition of Hearing and Consciousness

It is a point worth knowing, that *hearing* is one of the senses which may be abolished rather late in the induction, and that the patient under such circumstances may hear all that is said about the operation which is to be done. In fact, the complete abolition of consciousness need not always take place when morphine has been administered, and minimal quantities of the anesthetic are used. Thus, I recall an instance (P. R. No. 4324) in which during a suprapubic plastic the patient, although insensitive to pain, was able to converse with me throughout the entire procedure. Others have no doubt had similar experience. This illustrates that *analgesia* sufficient for the purpose of the surgeon, must not invariably be accompanied by complete unconsciousness.

Abolition of Reflexes

During the narcosis it is better for the patient to be in a *tonic,* than in an *atonic* state, as far as this is not entirely incompatible with the requirement of the surgeon. A slight reaction, for example, when the initial incision is made is not always to be criticized; if the anesthetist is uncer-

tain, it is wiser to allow the patient to be a little too superficially, than at once too profoundly under the influence of the narcotic. With the deeper respirations of the patient, a few drops will suffice to annul the wakening effect of the initial incision when the anesthetist has regained his bearings. It is not to be lost sight of, that analgesia—freedom from pain—is the first aim of the narcosis, and the reflexes should be diminished or abolished *only so far as they become a hindrance to the surgeon.* When morphine has been administered, the reflexes may remain quite active, although the patient is in the proper state of analgesia, and in the correct surgical plane. If the surgeon is gentle in his work, as he should be, not only on account of the delicate make-up of the structures which he is handling, but also in order to avoid any unwarranted exaggeration of the numerous ingoing impulses to the cord and brain, this property of morphine will very rarely prove to be an objection to the use of the drug.

Erroneous Notion About the Induction of Shock

The notion that shock will follow, because some of the reflexes are still active during the course of an operation, is surely not founded on experience. If the patient remains passive and feels no pain, the prime object of the anesthesia is usually attained. In abdominal and pelvic surgery, it is not always in the patient's interest to insist on flaccid abdominal muscles during operation. The muscles may be *relaxed,* but they must not be *paralyzed* by the anesthetic. The surgeon who is too violent or precipitate in the execution of his work, will continually complain that the abdominal wound cannot be satisfactorily retracted, and the patient is insufficiently under the influence of the anesthetic.

This is a dangerous failing, and may lead the narcotizer of limited experience to attempt to *subdue* the resisting patient with the narcotic, instead of anesthetizing her. Crowding the anesthetic is one of the chief sources of trouble in drop-method narcosis. The insufficient dilution of the anesthetic with air incident upon crowding, brings with it the inhalation of vapors which are too irritating to the glottis because of their great concentration. The increasing spasm of the larynx which results, impedes free respiration, and instead of anesthesia, a state of asphyxia is induced, which finally culminates in respiratory collapse. A change in the quality of the breathing sound indicated by the appearance of a few faint high-pitched notes, together with the advent of a slight tinge of cyanosis, are the significant premonitors of this condition. It is then not *more* of the anesthetic, but *less* of it, that the struggling patient wants. A little fresh air admitted by raising the mask, dissolves the spasm of the larynx, and strange as it may seem to the inexperienced, the patient who now inhales the diluted vapors freely, instead of awakening, relaxes the resisting muscles and relapses into a tranquil narcosis. The secret of success in an anaesthol or for that matter in a chloroform narcosis, lies in the systematic avoidance of crowding.

The Chief Failing in the Use of Chloroform or its Combinations

Coughing should not necessarily convey the impression to the operator that the patient is about to become conscious. It is frequently due to irritation of the pharynx, and may occur at any time during the course of the operation, if the mask is suddenly charged with the anesthetic, instead of supplying it uniformly, drop by drop.

The Coughing Reflex

Vomiting Vomiting efforts constitute a disagreeable interruption, but the deep breaths which are interpolated make it easy to regain the surgical plane. The head of the patient is quickly turned to one side *without pushing the jaw forward,* the mouth wiped and the anesthetic continued, while the surgeon co-operates by desisting for the moment from traction on the mesentery, or other manipulations which may have given rise to the potent awakening impulse.

Venous Blood Very dark blood at the wound may indicate that the patient's breathing is embarrassed. The cause may be mechanical, as when the saliva accumulates in the mouth, or the tongue recedes, or a shoulder-brace presses against the throat, or there is valve-action of the lips in the old who have been wearing a tooth-plate, or adenoid obstruction in children. When it is not feasible to remove the adenoids before operation, I know of no simpler way of coping with this difficulty, than by the use of the *breathing tube.* A soft rubber catheter is passed through one, or both of the child's nostrils, beyond the adenoid ring of Waldeyer into the laryngo-pharynx (Practical Points in Anesthesia, 1908). This manoeuvre is not only useful in the case of adenoids, but also in some of the other causes of mechanical obstruction, such as recession of the tongue. Occasionally, its use may be of *diagnostic* value in satisfying the anesthetist that the respiratory impediment in a given case is due to laryngeal spasm—the usual result of insufficient dilution of the anesthetic with air.

The Breathing Tube

Pulse It is a good rule for the surgeon to make a mental note of the *quality* of the patient's pulse before the operation. He is then in a better position to judge

the post-operative condition, or to appreciate any marked change in its normal characteristics. In weighing the necessity for post-operative stimulation, the surgeon should not allow the fact to escape him, that nausea and vomiting, occurring as the subject recovers from the anesthetic, may cause a transitory irregularity in the pulse which is of no serious significance. Furthermore, in the case of some anesthetics, as anaesthol or ether, a stimulant effect of the narcotic upon the pulse may occasionally persist for a very brief period after operation.

Estimating the Amount of Post-operative Shock

The amount of shock to which the patient, in a particular case, is subjected, does not depend so much, for example, on the actual *extent* to which the abdominal viscera are handled, but rather on the *manner* in which this is done. Thus, the entire mass of small intestines can be gently withdrawn from the abdominal cavity for systematic inspection, without of necessity producing in the patient the slightest evidences of post-operative shock.

Heart Disease in Anesthesia

A great deal might be said about apparent and real contra-indications to the administration of anesthetics. A common, but erroneous impression is that heart murmurs corresponding to a valvular lesion, necessarily contra-indicate narcosis. As a matter of fact, it is not so much the hearts that have murmurs, least of all the hearts that have loud murmurs that presage a perilous narcosis, but the *degree of myocardial involvement* is the salient factor. Thus, the heart with a degenerated muscle, scarcely capable of producing an audible murmur, commands the greatest solicitude during the administration of the anesthetic. Particularly pure chloroform, is out of place in such a lesion.

Epilepsy

Epilepsy does not contra-indicate the giving of an anesthetic, nor the execution of an operation; in fact, epileptic seizures of reflex origin, occasionally disappear after a simple narcosis or operation.

Anesthesia in Tuberculous and Diabetic Subjects

Great judgment must be exercised in establishing the indication for narcosis and operation in all subjects with tuberculous lesions of the lung; the danger lies in the exaggeration of an active process, or in the enkindling of a latent one. Moreover, operation performed in a tuberculous territory, in any part of the body, it is well known, may lead to dissemination of the trouble. In diabetic patients, where there is 2% or more of sugar which is not influenced readily by diet, coma is very prone to follow narcosis and operation, and seems to be directly or indirectly precipitated by these measures. It is in these two groups of cases, that both ether and chloroform or its combinations have distinct disadvantages, and while there is available no entirely satisfactory form of narcosis, nitrous oxide-oxygen correctly administered, holds a legitimate place. It may be that as soon as the construction of the necessary apparatus can be simplified, and its weight and bulk reduced to make it really portable, the nitrous oxide-oxygen sequence will receive the wider application in practice, which it deserves.

The Choice Between Chloroform and Ether

While I have repeatedly voiced the use of anaesthol—chloroform modified to increase its safety without impairing its anesthetic usefulness—as an acceptable substitute for chloroform in every-day practice, I would not convey the impression that I am inimical to the choice of an *uncombined* ether narcosis, only in so far as it is not practical. In addition, it is clear that the rigid adherence to any

routine, would be foreign to one who believes in adapting the anesthesia to the peculiarities of the case. As a routine procedure, it is true, the morphine-anaesthol sequence with or without the addition of ether, allows considerable latitude for individualization. But this will not always suffice to meet the special requirements in special cases.

Narcosis in Operations on the Brain and Cranial Nerves

In operations on the brain and cranial nerves it is not difficult for the anesthetist to maintain the surgical plane, because the awakening stimuli set up during the operation are slight. But it is a distinct advantage to have the anesthetist away from the surgeon's precinct. Instead of using the ordinary mask, the anesthetic is therefore administered through a funnel, covered with gauze, and connected with one or two rubber tubes which conduct the anesthetic vapors. In this very simple form of tube narcosis, the tube passing the base of the tongue enters the laryngo-pharynx, but not the larynx itself. If chloroform or anaesthol are used, and a full dose of morphine was given half an hour before the narcosis, to diminish the amount of anesthetic required, it ought ordinarily to be a comparatively easy matter to keep the patient sufficiently under the influence of the narcotic. If there is difficulty experienced in doing this, it may be that the calibre of the tube or tubes employed is too small. In a cerebellar tumor, or a tumor of the acoustic nerve, when an occipital flap must be made, and the patient's face is turned downward, the anesthetist may be seated at the foot of the patient, or, in some cases, advantageously out of the way of the surgeon and his assistants and nurses, on a stool *beneath* the operating table itself.

Narcosis in Tumors of the Larynx

In extrinsic tumors of the larynx, after opening the throat by subhyoidean pharyngotomy, the narcosis by this method is not feasible. The tube instead of merely approaching the vicinity of the larynx, must be passed into it and the trachea. The surgeon selects a rubber tube of about the thickness of a stomach tube which has been sterilized for the purpose, and introduces, first, the end with the eye, into the trachea, ascertains that the respiratory air streams freely through it, and then, at once delivers the other end to the anesthetist, upward through the patient's mouth, where it should be fixed with adhesive plaster to prevent dislodgment. In this manner the asepsis at the field of operation is not violated, as it would be, if the tube were first passed through the mouth into the surgeon's hands, before reaching the trachea.

Intratracheal Insufflation Narcosis for Intrathoracic Operations

In operations in which the pleura has to be opened, or may be opened accidentally, it becomes vital to *prevent collapse of the lung.* In the intratracheal insufflation method of anesthesia developed by Meltzer and Auer, this difficulty is obviated in a strikingly simple way. Here a single rubber catheter which is not too thin-walled, and about No. 22 French scale, is introduced to the vicinity of the bifurcation of the trachea, and a stream of oxygen mixed with ether vapor of a concentration not exceeding 6 to 7 per cent., serves the double purpose of assisting in the inflation of the lungs, and maintaining the anesthesia. To avoid the repetition of fatalities caused by abrupt distention of the lung, no apparatus of this description should be used on the human subject, unless it is supplied with an adequate safety valve (H. Fischer).

Since the creation of the first separate department for intrathoracic surgery in this country, at the German Hospital of this city—the result of the untiring energy of Willy Meyer and his brother, J. Meyer—unique opportunity for the study of the comparative value of these methods is afforded. I had occasion to be incarcerated in the positive differential pressure compartment repeatedly, when the first trials of this modified Sauerbruch-Brauer chamber were made at the hospital, and it seems to me that the current impression of the great discomfort of the narcotizer, and the difficulties that beset him under these circumstances is not well founded. The vapors of the anesthetic do not accumulate in the chamber, the space is sufficiently large to accommodate an assistant if one should be needed, it is possible to leave the cabinet through the vestibule, without exposing the patient who is under narcosis to a sudden change in the atmospheric pressure. Outside of the slightly disagreeable sensation produced in the ear-drums of the occupant when the pressure within the cabinet is raised or lowered, and the disturbing vibration caused by the action of the ponderous pumps, the conditions under which the anesthetist has to work are but little different from those in the ordinary operating-room. The air-tight rubber collar somewhat encumbers the manipulation of the patient's head, but the difficulty is largely overcome when the latter is placed on a small head-rest which is suspended in an adjustable sling or hammock. In the administration of the anesthetic, in general, the same rules hold good as in narcosis elsewhere—the apparatus has to do only with the counteracting of the abnormal rise in pressure produced in the

Anesthesia in the Positive Differential Pressure Cabinet

pleural cavity by the inrush of air when the thorax is opened, and to prevent the lung from collapsing thereafter.

Death by Asphyxia

During one of the operations executed with the aid of the apparatus, I have had occasion to observe a peculiar series of events during which the pupils dilated and the patient rapidly collapsed, and which I have been unable to explain, except that it appeared likely that the fatality was not due to the action of the anesthetic or any unusual manipulation on the part of the anesthetist, but rather the result of some manoeuvre incident upon the operation itself. Dr. J. Meltzer has, I think, offered the first scientific solution. He emphasizes that under the Brauer method, life is sustained by a small part of the normal respiration (minimum, 1/10th of the normal). The only portion of the lung which is active in aeration under these extreme conditions is the posterior part of the lower lobe. Any manipulation on the part of the surgeon which interferes with the function of this portion of the lung, such as pushing it to one side during exploration, or compression of it, or expulsion of its air content by dislodging it, or lifting it out of the chest, may suffice to bring about a rapid exitus by asphyxia.

At the present time, when thoracic surgery has just received a new impulse, it is impossible to pass final judgment on the relative practical value of the differential and intra-tracheal insufflation methods of anesthesia. However, the general drift seems to be towards the adoption of the intra-tracheal insufflation method for routine thoracic surgery, limiting the scope of the differential pressure method to special cases.

CHAPTER IX

The Incision

In surgical treatment the division of healthy tissue often becomes necessary, in order to make the seat of disease or injury accessible. Since the integrity of the structures which have been *deliberately divided* must again be restored, it is a matter of moment *how* this division is done. Operations on the abdominal and pelvic organs form such a large part of the routine in major surgery, and the abdominal route is so frequently chosen, that a careful study of the parietal incision with the view of avoiding disagreeable sequelae such as neuralgia, deforming scars and post-operative hernia, is distinctly worth while. But the ideal incision, besides being in itself a conservative one, must allow of extension without undue mutilation of the anatomic entities which constitute the abdominal wall. Viewed in this light, very few of the stereotype methods ordinarily practised can be considered exemplary.

Conservative Incisions

One of these, however, which illustrates the general principles involved in the make-up of correct parietal incisions, has been pointed out by Pfannenstiel, Stimson and others for operation on the pelvic organs and the lower abdomen—*the semilunar hypogastric incision combined with the median separation of the recti.* The incision is carried across the abdomen in a shallow curve, the convexity of which usually corresponds to a point one-half to three-quarters of an inch above the symphysis pubis. It begins and ends one and a half inches or

Semilunar Hypogastric Incision

less, above the midpoint of Poupart's ligament on each side. Its correct course is indicated by the furrow or sulcus of a more or less pronounced suprapubic fold, which is found in this location.

Since the greater portion of the incision lies in the hairy area of the pubic region, the difficulty of rendering the skin aseptic may be cited as an objection to its general use. But experience has shown, I think, that such an objection does not militate against its adoption. If the area is carefully shaved, and cleansed with soap suds when the patient is admitted, and on the evening before operation any one of the compatible iodine solutions is applied for preliminary disinfection of the points which are inaccessible to the final mechanical cleansing in the operating-room, and the skin is kept covered during the operation with sterile towels which are prevented from dislodging by means of Backhaus' towel clamps, there need be little fear that contamination of the wound will occur from a surface which is not surgically clean.

Division of the Subcutaneous Fatty Tissue

In the semilunar hypogastric incision the subcutaneous fat, that is, the *superficial* layer of the superficial fascia or Camper's fascia, is split at once down to the dense structure which represents the *deep* layer of the superficial fascia, Scarpa's fascia. The depth of the wound at this stage varies greatly with the development of the panniculus adiposus and may be less than one-quarter inch or more than two inches. The amount of venous bleeding also varies, and is naturally greater when there is venous stasis. Most of the bleeding from the fat is due to venous oozing, and is arrested by means of dry gauze, or if this fails gauze sponges wrung in boiling water. Usually it is only four points that have to be

secured by hemostatics—the divided ends of the *superficial* epigastric artery, in the right and left halves of the upper and lower flaps. The branches of the superficial external pubic on the other hand, which ascend to the zone just above the pubes, are so minute that they do not require clamping at all. The bleeding points need rarely be ligated; by the time the wound is closed, or before this, forcipressure alone will have sufficed to insure hemostasis. Ligating these vessels merely consumes time, hinders the re-establishment of the blood flow across the scar, while the knots of catgut, until they are disposed of, act as foreign bodies in the wound.

Scarpa's Fascia and Anterior Rectus Sheath

By means of the gloved index finger, covered with a layer of gauze, the loosely attached fat is easily brushed from the surface of the dense fascia, exposing it to view, and widening the path of the incision. Scarpa's fascia is intimately adherent to the anterior rectus sheath, and the separation would be more or less artificial, so that in this procedure both are best treated as if they constituted but a single layer. The scalpel is carried through the structure transversely on each side of the median raphé, until the red muscle appears; a small blunt scissors is slipped into the opening, and the incision is extended to each side. While the incision through the *skin* follows the lines indicated by the natural crease, and is, as a rule, a *shallow curve,* the line of *fascial division,* should approach a *semicircle,* in order to obtain a flap which permits of better exposure. This point, I believe, is sometimes overlooked, and its non-observance may help to explain the difficulty which is occasionally experienced in getting sufficient working room with the semilunar hypogastric incision. The normal limits of the

incision are the lateral borders of the recti muscles; in other words, it does not extend beyond the lateral confines of the rectus sheath, so that the dorsal nerves which enter it here to supply the muscle are not cut. As a rule, *any* separation of living tissues from each other which is not imperative, is to be looked upon as harmful; but it is, in this case, *essential* to free the unyielding fascia from all its subjacent connections. This is easily done by lifting the border of the upper fascial flap, first on one, and then on the other side of the median raphé, while the index finger is passed beneath it and strips it away from the anterior surface of the rectus muscle. Sometimes a few strokes of the scalpel, may be required to free the sheath from a tendinous inscription which occurs at this low level. The median raphé is then divided by means of scissors, while it is put upon the stretch between forceps. The division of this line of attachment must be continued upward to the extent of two or three inches. In a similar manner, the inferior fascial flap is separated as far as the crest of the pubic bone. Beneath the fascia, the rectus abdominis muscle is attached by a tendon to the crest of the pubes. When the pyramidalis muscles are absent, there may be noted in their stead, in front of this tendon, near the median line, a small tendinous process which can be traced to the anterior surface of the symphysis pubes, when the lower fascial flap is raised. At this stage, the lower flap of fascia is incised in the middle line, as far as the pubic bone—pubic extension. The incision is only one-half to three-quarters of an inch long, so that the danger of post-operative hernia at this point may be disregarded, while the advantage gained in securing a wider ex-

Lifting the Fascial Flap and Liberating the Rectus Muscle

posure is so decided, that it seems best to use the pubic extension as a routine.

To understand fully why the recti muscles are so promptly mobilized, and can be pulled away from the median line like two yielding, elastic bands, it must be borne in mind that in this location the resistant rectus sheath is absent posteriorly, and the muscle is but loosely connected with a supple transversalis fascia and peritoneum. The replacement by a narrow strip of rigid connective tissue of one or both pyramidalis muscles, likewise affects the readiness with which the recti muscles can be retracted. When the pyramidalis muscles are present, the opening is usually effected by entering between them; sometimes it is indicated to enter to one side. In either case, some mutilation of the tapering apices can hardly be avoided.

On retracting the muscle bands with McBurney retractors, the transversalis fascia and peritoneum present themselves, and are opened at a high level in the wound, by making a minute incision between forceps. With the inrush of air, the intestinal coils at once recede and the peritoneal opening is enlarged, at first upward, and then cautiously downward, to avoid incising the bladder. The summit of the empty bladder reaches the level of the pubic crest. By palpating the peritoneum between the thumb and finger, or by raising it so that it can be trans-illuminated before dividing it, accidental injury to the bladder can easily be prevented. A thick layer of properitoneal fat should not be mistaken for adherent omentum. If in doubt, it is severed cautiously in a *perpendicular* line, when the peritoneum itself will soon appear and the small bowel can be seen to move freely beneath it. In the pro-

Section of the Transversalis Fascia and Peritoneum

peritoneal fat, between the transversalis fascia and the peritoneum, lie the deep epigastric arteries on each side, accompanied by their venae comites. But, approaching in their upward course, the fold of Douglas, they pierce the transversalis fascia and enter the rectus sheath. In this part of their course they lie between the posterior surface of the rectus muscle and the posterior lamella of its sheath. It is well to be heedful of this relation. I have in mind a fatality in a case in which an autopsy was not obtained, in which it seemed likely that exitus was due to internal hemorrhage from the deep epigastric artery injured in abdominal repair.

Suture of the Wound

At the close of the operation, the wound is repaired layer by layer. The peritoneum is closed with a contiuous spiral suture of No. 0 40-day chromic catgut, while a hemostatic at the upper and lower angles of the opening, lifts it away from the bowel. To accelerate this step two stitches are taken each time before the catgut thread is tightened. To correct the recession of the peritoneum from the abdominal parietes as it approaches the top of the bladder, and to give this point additional support, one or two interrupted sutures of No. 1 or 2 40-day chromic catgut may be employed to bring the muscles together, and allowed to traverse the space of Retzius, including the fibrous cord, the obliterated urachus, which can be felt as a thickening beneath the peritoneum. When the repair of the muscle layer is complete, palpation of the suture line with the finger, above all, at the upper and lower angles of the incision, should reveal a uniformly firm resistant seam, without any yielding interstices. Exceptionally, for example, in pre-existing diastasis of the recti, simple or compound, interrupted mattress

sutures may be indicated, and the attenuated muscle planes are overlapped. In closing the fascial incision, it is to be observed that the anterior rectus sheath which is here, in itself, quite thick, being formed by the complete fusion of the aponeurosis of the external oblique, the internal oblique and the transversalis muscles; is also re-enforced, by the deep layer of the superficial fascia—Scarpa's fascia —which is particularly well developed, and rich in elastic fibres. In general, the anterior rectus sheath and Scarpa's fascia are found to be quite adherent, although at the angles of the semicircular incision their individuality is easily demonstrable. After both layers have been made to coincide at the ends of the wound, the angles are clamped temporarily to aid the suture *en masse*. Before this step, the patient must have been returned from the Trendelenburg to the horizontal posture, to obviate unnecessary tension. As a rule, the tension is not marked; if notable, it is most apparent in the center of the incision, and at this point a few interrupted sutures of No. 1 or 2 40-day chromic catgut may be placed, while the remaining wound is repaired by means of a continuous glover's stitch, of the same material. When the pubic extension has been practised, both corners of the fascial flap thus formed must previously be caught with clamps and reunited. A simple mattress stitch is most efficient in bringing together the corners, and drawing them, at the same time, upward against the margin of the upper fascial flap at its midpoint. To prevent gaping, a continuous spiral suture of No. 000 or 0 40-day chromic catgut is introduced into the subcutaneous fat when it is abundant, that is, when the layer exceeds a quarter inch in thickness. Skin

Successive Steps in Closing the Wound

coaptation is accomplished by means of Michel's clamps, which are removed at the first dressing, on the fifth or seventh day. By this method, generally the most satisfactory closure of the skin wound is obtained in this region. In many cases there remains a scarcely discernable scar hidden in the recess of a natural fold. The removal of stitches or clamps can, of course, be altogether circumvented, by using a properly chromicized catgut filament. No. 000 catgut of 40-day resistance will be absorbed in due time, that is, approximately in five to twelve days. The subcuticular suture, or zinc oxide adhesive strips, are not as practicable in closing this incision as they might perhaps seem to be. The subcuticular suture is difficult to apply to any semicircular flap without obtaining an uneven apposition, while sterile zinc oxide strips are apt to adhere imperfectly, and become detached subsequently under the influence of the sebaceous secretion, together with the traction exerted upon the wound when the patient awakes.

The prime object of incisions, to gain satisfactory exposure, may be sacrificed unwittingly when important accessories are overlooked. In a pelvic operation the surgeon may be struggling to get the intestines out of the field and the pelvic organs into better view; he may criticise the incision, the retraction by his assistants, or his anesthetist for insufficient relaxation, while he is totally unconscious of the fact that the patient has not been put into the proper Trendelenburg posture which allows the intestines to gravitate towards the diaphragm, while the pelvic viscera prolapse into the wound. Similarly, the reverse posture may be helpful, or

Correct Posture

an inclination of the patient's body to the right, or to the left during an operation.

Other Methods of Opening the Lower Abdomen

In the greater number of conditions which the surgeon has to deal with in the lower abdomen and pelvis, particularly in the female patient, satisfactory access is afforded by the semilunar hypogastric incision, and its increased complexity need not be in the way of its choice. However, when the time involved, is a very important factor a less intricate method of opening the lower abdomen may be legitimately employed. The simple median vertical incision, which violates nearly all of the principles that are important in reparable incisions, may be the only alternative. This technic may, however, be very much improved in a simple manner, if the opening into the fascia is made somewhat *extra-median,* so that the tongue and groove principle indicated by Frederic Kammerer in his right rectus incision, can be applied. After section of the skin and subcutaneous fatty tissue in a vertical line parallel to the midline of the abdomen and about one inch to the *left* of it, the anterior lamella of the rectus sheath is split in the same direction. By blunt dissection the mesial border of the rectus muscle is defined. After retracting it, the posterior lamella is cut in a line corresponding to the skin incision, *without injuring the deep epigastric vessels.* There is thus obtained a tongue and groove arrangement of the important fascial and muscular strata. The tongue is represented by the border of the rectus muscle, which fits into the groove formed by the mesial part of the anterior and posterior lamellae of the rectus sheath. When this incision is made over the *lowest one-fourth* of the rectus muscle, where the posterior lamella is deficient, the poste-

The Mesial Rectus Incision

rior lip of the groove which receives the rectus is represented only by the transversalis fascia and peritoneum. When a longer incision is necessary which extends beyond the level of the fold of Douglas, the posterior lip in the upper part of the incision becomes a more massive structure. There can be little doubt that the contractile muscle placed behind divided fascial and aponeurotic layers in this incision, is helpful in preventing postoperative hernia.

Deep Epigastric Artery

In order to avoid injuring the deep epigastric artery needlessly, by encroaching upon it while extending the division of the posterior lamella upward, its general course can be traced out roughly by a line drawn from the midpoint of Poupart's ligament to the umbilicus.

Lineae Transversae

The development, number or absence of the lineae transversae, is also of some significance. Along the lineae transversae the anterior lamellae of the rectus sheath—but not the posterior—may be quite adherent, so that it may be impracticable to attempt dissecting around the border by the blunt method. In these cases the knife-blade must be used to free the muscle. Usually such an intersection is found at the level of the xiphoid process, another near the umbilicus, and one about midway between these two points. Sometimes one occurs *below* the umbilicus, between it and the pubic symphysis. Although the technic of the incision is somewhat encumbered by the presence of these tendinous intersections, they facilitate the secure suture of the rectus to the bottom of the groove when the wound is closed.

In the lower abdomen such an incision might be substituted for the semilunar hypogastric, in case of tumors which are so large that they cannot be

delivered through the maximum opening obtained by the former procedure. For instance, when a fibroid tumor or an ovarian cyst reaches the umbilical level or extends beyond it. It may also be in place, when a large pus focus has to be dealt with, or in an operation for advanced cancer, or finally, when the patient's vitality is low, the case is urgent, and time becomes a more important factor.

Indications for the Incision

The method which I have outlined, may be appropriately designated, the *mesial* rectus incision, to distinguish from the *lateral* rectus incision in which the lateral, not the mesial, margin of the rectus muscle has to be retracted. In the lateral rectus incision, both retraction and extension of the incision are anatomically limited—the former because of the liability of injuring the dorsal nerves as they enter the lateral border of the muscle to supply it, the latter, because these nerves cross the path of the incision.

The Mesial Rectus Incision not the Lateral

The principles which are apparent in the analysis of routine incisions in the lower abdomen, are, in general, valid when the parietal route through the *upper* abdomen is chosen. Similarly, a routine incision in this region must be so outlined that it will suffice for the thorough examination of the gall-bladder and ducts, pancreas, stomach and duodenum; it should be capable of such extension as operations on these organs may necessitate. The posture of the patient is here also none the less vital, particularly for the proper presentation at the wound of those organs, which lie close to the vault of the diaphragm, or, in overcoming difficulties when the incision is small, or unfavorably situated.

Routine Incisions in the Upper Abdomen

In place of the *routine* incision, a number of *special* incisions into the abdominal wall, have been

devised by various surgeons for exceptional cases. They are indicated, when extension of the incision, or exploration is not deemed necessary. It is a good rule to make use of such an incision only, when it is unlikely that there is an error in the diagnosis. An exception may sometimes be made, when the surgeon has before him a sudden, severe, acute abdominal condition, which demands surgical investigation at once, before he can decide whether the trouble is located in the upper or lower half of the abdomen. An acute appendicitis is naturally to be considered first because of its relative frequency, and a Kammerer right rectus incision or a small McBurney incision in the right iliac region may be made with this in view. In order to meet complications arising from errors in the diagnosis of *chronic* appendicitis, and to facilitate dealing with the surgical conditions which may simulate this trouble, Robert F. Weir suggested his method of *extending* the McBurney intermuscular incision. Again, when chronic appendicitis occurs together with a right inguinal hernia, both may be attacked through a single skin incision. Such a technic was described by Franz Torek (Annals of Surgery, May, 1906), and also, in one of my cases, which presented some complications, by A. H. Harrigan (The Combined Operation for the Radical Cure of Inguinal Hernia and Appendicitis, Medical Record, June 26, 1909).

Special Incisions

Before he approaches the operation, the surgeon should have a definite plan of procedure which is not based on the observation of others, but on his own critical analysis of the case. The chief complaint of the patient, that for which relief is sought, the best route of attack; the possible error in diag-

nosis, and the complications in the surgical technic which this may involve; all, must have been considered beforehand. Whenever an exact diagnosis cannot be made, the incision assumes an *exploratory* character. A *small* incision can be widened, or readily closed, and a second incision made in a more favorable situation, when the real nature of the trouble is revealed. Thus, in a patient who has had a slight rise in temperature for some time previous to her operation, if a retroperitoneal tumor connected with the kidney is discovered, on account of the greater safety, good surgical judgment may demand the selection of the retroperitoneal route through a lumbar, instead of a ventral incision.

Choice of Incision

At the present day, when so much has been done to make surgery an exact procedure, the various modes of gaining access to the site of disease in the human body, deserve critical consideration. It is not always the simplest technic, which is at the same time the most conservative, and the best. Important details in a method, cannot conscientiously be disregarded in the effort to attain unwarranted speed. An operation may be quickly *ended,* it takes longer to *complete* it, still longer to *finish* it.

CHAPTER X

The Course of the Operation

Orderly procedure calls for the definite division of labor at an operation. It helps to save time, and to conserve the surgeon's energy for the more vital phases of his work. It is not an easy matter to train assistants, and to operate at the same time. However, it lies in the nature of every-day practice, that men unacquainted with each other's peculiarities, occasionally have to work together. In general, there ought to be a clear understanding beforehand, about the division of labor at the operation. The surgeon who makes the plan for treatment and executes the operation, at once assumes the undivided responsibility for the physical well-being of his patient; and whatever be the *individual* plan in the work assigned to those who help him, it must necessarily be subservient to his own.

Division of Labor

The surgical assistant exposes the structures so as to make them accessible, and assists the operator *directly* at every step. When it becomes necessary to *retain* exposure for a longer period, a second assistant, or in his absence, the nurse at the instrument table, assumes this function. Thus, the first assistant's hands are left free to work with the surgeon. In operations on the spine, or in transthoracic surgery, where the interfering structures are relatively inelastic and rigid, it may be practical to substitute self-retaining retractors for one of the assistants, but in most cases there is no device, which can hold or guide the retractor as well as the human hand.

First and Second Assistants

Since the plan of procedure is properly formulated by the surgeon on whom all the responsibility for the success or failure of the undertaking devolves, the assistant should not consider it within his sphere, to suggest. Sometimes there are brief periods of relaxation during a tedious operation when the surgeon ceases, for the moment, to exercise his critical judgment in the usual way. Perhaps he has been under a continued strain from previous cases, or is exhausted in body and mind from night-work and lack of sleep. At such a juncture, he may spontaneously give expression to his indecision, and a *mature* assistant may do much to aid him. Notwithstanding this, it is an impress of good training, to offer no suggestions, however tempting the situation may be, unless these are solicited, and then only with the greatest caution and reserve. Of all concerned in the operation, it is the surgeon pre-eminently, whose conception of the condition which presents itself, is apt to be the most profound, and who, while *executing* the work, alone is in a position to follow every phase of the situation. It is for him, therefore, and not for his assistants, to decide, what is to be done at a critical turn. Indeed, the psychology—the mental processes—during an operation ought to be of practical interest. Most of us have experienced, that in a time of indecision, the mind may be unduly receptive to an extraneous idea—a plan is quickly adopted without passing the usual muster. When the operation is over, an afterthought brings with it the realization that an error in judgment has been made.

Assistant's Function

The experienced operating-room nurse, in a measure, anticipates the surgeon. Needles are threaded beforehand, and the instruments are ar-

Function of the Operating Room Nurse

ranged on the instrument table according to some logical scheme to which she has accustomed herself. For instance, she may separate into groups,

(1) Instruments for the *grasping* of structures, and exposure of the field; tissue forceps, tenacula, volsella, retractors.

(2) Instruments for the *cutting* or division of tissues; scalpels, scissors, saws, bone chisels and mallet, rongeur forceps.

(3) Instruments for the *clamping* of blood vessels, or hollow organs; hemostatics, clamps for the broad ligament, stomach, bowel.

(4) Instruments for *tissue-repair;* needles, needle-holders, and suture material; Michel's skin clamps; drills and wire; Lane's plates.

It is the technical part of the operation which consists of *exposing, cutting, clamping* and *repairing,* to which her attention is directed. She groups the acts of the surgeon under these headings, as she selects the instruments which are to be held in readiness for a particular step. Thus, for example, the initial incision is preceded by draping and the application of towel clamps; then come a scalpel and two sharp retractors. Bleeding which follows, demands sponges and hemostatics; subsequently, catgut and scissors. In this way, each act of the surgeon throughout the operation, evokes on her part, a well-directed response. The instruments which are immediately necessary are kept on the Hartley table within his easy reach, and those which become unnecessary are promptly removed.

The family physician is often present at the operation. His correct function, is not that of a surgical assistant, but more properly that of a *medical consultant.* In this capacity, he moves in his natural

sphere of usefulness, and is thoroughly unconstrained. His concrete impressions of the chief complaints of his patient, his accurate knowledge of her debilities, idiosyncrasies, and her recuperative powers under various conditions, the effect of previous operations, all may be of value to the surgeon in determining his plan. The presence of many consultants, on the other hand, should scarcely ever be indicated. Many of us have seen this prove to be an embarrassing complication. The extraneous influences which are thus added, serve merely to distract the surgeon, and may, to the patient's disadvantage, sway him from his wonted course. Besides, opinions differ in regard to details of personal experience; many consultants are like many clocks —they are apt to disagree.

The Family Physician

In dividing tissues and separating structures from each other during an operation, it is not to be overlooked that the more extensive the surgical trauma which has been inflicted, the greater will be the demand upon the organism in the subsequent process of healing. When the separation of layers, or the isolation of vessels, nerves and other structures can be avoided, it is usually in point to do so. In this sense, a good dissection may become a faulty operation. The principle applies to numerous operations which are commonly practised. In the case of an inguinal hernia in the male subject, demonstration of the *individual* structures of the cord by dissection, except in so far as the technic of the hernioplasty absolutely requires it, is of questionable value. Similarly, it is a decided technical error to isolate the ureter needlessly from its bed, in operation in its vicinity. In general, the extensive freeing and demonstration of vessels and nerves, is not in strict

Avoidance of Dissection

accord with the fundamentals of conservative surgery; the healing process invariably calls for *some* scar-formation about these delicate organs, which may ultimately lead to constriction or impairment of their nutrition.

When a deep blood vessel has to be tied, it is a simple matter to *transfix* the suture. This precaution ought always to be taken against the possible slipping or dislodgment of such a ligature. Tying vessels *en masse,* is unsurgical; the hemostasis is imperfect, the grasp of the ligature insecure. Thus, many accidents from postoperative hemorrhage have at one time followed the employment of Tait's figure-of-eight knot, in salpingo-oophorectomy.

Safe Hemostasis

Marked bowel distention may prove to be quite an encumbrance, on account of its interference with retraction and exposure. It occurs not only in peritonitis, that is, in inflammatory conditions, but as well, without actual inflammation, for example, after internal hemorrhage. Of course, no effort on the part of the anesthetist will relieve the difficulty. It calls for adequate posture of the patient, and careful walling-off of the bowel to prevent its continual prolapse into the wound.

Difficulty Due to Bowel Distension

Retraction should always be gentle and elastic. Organs like the brain or liver require particular care. Nerves should not be caught with the ordinary thumb-forceps, but cautiously drawn aside by means of a small hook, or lifted out of the way with a small thumb-forceps with thin blades which are bent slightly at the end so that the structure can be picked up without contusing it—*embracing-forceps.*

The Embracing Forceps

Finally, surgical wounds which have been inflicted, must be repaired. The needle which is most universally useful is curved; its curve corres-

ponds to *one-half of a circle.* Its size might be rationally indicated by the length of its cord, in other words, the distance between the point and the eye. Since much of the work in surgery has to be executed within narrow confines, a needle with a *shallow* curve, for instance, a quarter-circle, or less still, a *straight* needle, is awkward to introduce and to deliver, during the application of the suture. The path traversed by the *semicircular needle,* on the contrary, corresponds to the natural turn of the hand and wrist, and the point enters the tissue-planes and emerges from them in a vertical direction.

Choice of Needles

Whether the needle in a particular case is to be *round-bodied,* or whether it should have a *cutting* edge, depends on the nature of the structures to be united. If one were guided by theoretical considerations alone, the round-bodied needle might be given the preference, because, where it can be used, it appears to subject the tissues to the smallest amount of traumatism; it penetrates by *separating,* rather than by *cutting* them. In practice, however, there are salient objections to it. Round-bodied needles can be carried through dense structures only with considerable difficulty, and often at the risk of breaking the needle. Besides, there is the additional disadvantage that the smooth, round body easily rotates within the jaws of the needle-holder, unless the latter is supplied with a catch. The usefulness of round-bodied needles, on this account, extends but rarely beyond the repair of surgical wounds of the stomach or bowel, or of a tear or cut in a parenchymatous organ. For the great mass of plastic surgery, it is best to select needles with a cutting edge. Probably the most generally useful of all, in surgical

routine, are those which are *quadrangular* towards the eye where the needle-holder grasps them, but *triangular,* with a cutting edge and bayonet point, in the engaging portion—*semicircular needles with bayonet points.* The so-called *sinus needles* have flat bodies; they slit the tissues easily and are readily broken during sewing manoeuvres, because the strain is directed against the shorter and weaker axis of their bodies. Conversely, the curved *Hagedorn* needle is flattened from side to side, the longer axis of its body is sufficient to resist the bending strain put upon it in suturing, so that it is seldom broken, but it is not well adapted for use in a plain needle-holder.

Special needles are the *long straight* needles with a round body, which are useful for suturing the stomach or bowel, whenever these organs can be lifted up into the wound, so as to obtain ample working-room. Such needles are manipulated by the fingers in the manner of the seamstress, without the aid of a needle-holder. Furthermore, for the anastomosis of blood vessels, some technicians prefer to use a *"half-curved" needle*—a straight needle with a curved point. The curved end facilitates the engagement and delivery of the point, while, with some practice, the straight end makes dexterous manipulation possible without the aid of a needle-holder.

Walling-off a Pus Focus

While working in the *peritoneal cavity,* the best prophylaxis against general contamination of the peritoneum, consists in the thorough walling-off of the suspicious focus by means of gauze. Should an effusion of septic material take place, its escape into the peritoneal cavity is effectually barred. Small sponges ought rarely to be used; when a strip of

gauze cannot replace them, they should be *fed* to the forceps by the nurse, *one by one,* so that two of them cannot be picked up at once, the one being returned, while the other is lost in the wound.

Fluid Collections and Dead Spaces

Bacteria may be carried from the *skin* to the deeper layers, but cannot readily form colonies in contact with the healthy living tissue. In stagnating fluids, when proper tissue apposition is neglected, and so-called "dead spaces" are left in the wound, there are, however, presented all the conditions favorable to their growth. It is, because blood and tissue-lymph are excellent culture media for pathogenic organisms, that their accumulation in healing wounds should be scrupulously avoided. This is why, in wounds of the abdominal wall, when the panniculus adiposus is well developed, gaps in the fatty layer must always be closed. For similar reasons, after radical operation for cancer of the breast, a drain is inserted into the most dependent portion of the axilla, when the pyramidal space which is left after operation cannot be obliterated by suture, or by the use of an axillary pad. In inguinal and femoral herniae, drains are no longer used, because the spica, when snugly applied, efficiently coapts the fascial strata.

Fainting of a Nurse

The session in the operating theatre may bring with it untoward events. An occurrence such as the fainting of a nurse or an assistant should not be allowed to upset the strict regime. It is unwise, especially for a novice, to attempt the strenuous task which an operation imposes on every one concerned, with a fasting stomach or a considerable burden of clothes. If one of those in attendance requires attention, this should be given without, at the same time, violating the asepsis. In complications, in the

Collapse of the Patient

course of the anesthesia, such as collapse, be it cardiac or respiratory, the first thought is always to rid the patient of the residual anesthetic by prompt artificial respiration, while the surgeon protects the operating field with a sterile towel. The manipulations are executed by grasping both forearms of the patient near the elbow, and extending them over the head. After a brief pause, they are again returned to the side of the chest to produce a forcible expiration. This should be done rhythmically, and at about the rate of natural breathing. The anesthetist must see that the tongue is forward, and no impediment exists in the upper air-passages.

Hemorrhage

A large vessel may be cut or torn while operating. The pedicle of the right kidney is rather short and easily injured while delivering the organ through a lumbar incision. A profuse hemorrhage may occur from the renal vein, the wound is at once flooded with blood, so that nothing can be seen. Counter-pressure with the hand from the front, and a large tampon of gauze packed tightly into the bottom of the wound, may be the only alternative. An intravenous infusion of physiological saline may have to be immediately started, and little or no anesthetic must be administered for the time being.

Generally speaking, death during a serious operation in an enfeebled patient, is not sudden, but gradual. The anesthetist discovers the progressive failing in vitality, and such an indication should be promptly announced. Sudden death during operations, however, may occasionally occur, for instance, as the result of air embolism. The aspiration of air is most likely to take place through wounds in the *larger* venous trunks in the proximity of the heart, because, in these, during the act of inspira-

tion, the pressure becomes decidedly negative. Sometimes indeed, the aspiration of air is followed by dilation of the pupil and the breathing becomes labored, but the patient subsequently recovers. At all events, in such an emergency, the first thought is compression of the vein at the site of the injury, or on the heart-side of it, to prevent further aspiration. Meanwhile, the field is kept flooded with saline until the wound in the vein can be closed. If measures, as the forcible compression of the chest, combined or uncombined with inflation of the lung with oxygen by means of a tube passed through the patient's nostril, are indicated, and are really of therapeutic value, remains still to be ascertained.

Air Embolism

CHAPTER XI

Care of the Patient After Operation

Arrival from the Operating Room

The attentive, kindly nurse can do much towards minimizing the discomfort of her charge. Many patients sweat profusely after operation, and the wet shirt is promptly exchanged for a dry one, the covers are tucked snugly over the shoulders and chest; and, if the temperature of the room is low, or the patient's condition poor, hot water bags are applied at once to the side of the body and lower extremities. A chilling of the surface may mean suppression of the excretory skin activity, and additional work for the kidney which is already overtaxed. On the other hand, bronchial congestion following neglect, may lead to pulmonary complications which might have been avoided.

After the brief vomiting which sometimes follows awakening, the comfort of a soft pillow under the head, should not be withheld. The abdominal wound may be supported when the patient vomits, to lessen the pain caused by this sudden impulse; a pillow placed under the knees, reduces traction upon the suture. The patient's mouth is rinsed with lime-water or milk of magnesia, to remove the after-taste of the anesthetic; she may be allowed to inhale the vapors from a ball of cotton moistened with alcohol and acetic acid. The dry lips are kept moist; a wet cloth over the forehead and eyes, helps to induce sleep. The cloth should not drip, nor should water flowing from it into the patient's ear, escape

notice. During the first twenty-four hours after operation, one or two, or, if necessary, more doses of morphine sulphate, one-quarter grain each, are allowed hypodermatically. The first dose, is usually given as soon as the patient becomes restless. The second, not sooner than four hours later, when post-operative discomfort reasserts itself. Finally, on the evening of the next day, a third dose is generally indicated. It is well not to continue the administration of morphine any longer than is necessary. After many abdominal operations there remains on the second or third day, little more than *a soreness in the region of the wound and perhaps a dull ache in the back.*

Morphine

It is important to analyze the patient's complaint. The occasional, migrating pain in the abdomen, or the sharp twinge that comes and goes, and appears on the second day or later, is usually a *gas pain.* It has its origin in the paretic intestine, and not in the wound. The simple peppermint enema affords relief, while morphine would be only of transient value, and is not the logical remedy. It is the part of wisdom to avoid promiscuous medication. Personally, I believe that the treatment of a surgical case should be left entirely to the surgeon, all orders being issued by him until the patient is in a condition to be dismissed from his care.

Gas Pain

Unnecessary division of responsibility leads to a division of the plan of treatment, complicating instructions to the nurses, and is not for the best interest of the patient. Frequently, the surgeon's lack of knowledge of the dosage and action of drugs, has helped in this regrettable complication. It is rare indeed, that a drug is imperative in a surgical case, but where one is indicated, he should appre-

ciate the indication, and ought not to be at sea about the exact dose, vehicle and conditions necessary to insure the desired effect.

Axioms worth bearing in mind, are the following:

Anodynes and Somnifacients

(*a*) After operation, it is well to spare the rebellious stomach from drugs.

(*b*) Morphine is primarily not a somnifacient, but an *anodyne,* and the patient sleeps after its use because the disturbing pain has been relieved.

(*c*) Veronal, veronal-sodium, tetronal, trional, sulphonal, and allies, on the other hand, are, strictly speaking, somnifacients and not anodynes. These drugs therefore, cannot replace morphine for post-operative use.

(*d*) Of anodynes allied to morphine, eodeine phosphate and dionine are readily soluble in water, and can be given subcutaneously, but the action of these is feeble when compared with morphine, and, the instance in which their postoperative administration might be indicated must be exceptional.

No sleep is as refreshing, and as beneficial as the *natural* sleep. After the first few days when the meridian of pain has been passed, and anodynes have no purpose, it seems to me an error in judgment, to yield too readily to the patient's request for "something to make her sleep." A patient who

Sleep

is resting in bed all day long, cannot expect to sleep as soundly throughout the night, as she was wont to do after a day of bodily activity. A nervous unrest produced by anticipation of stitches to be removed, worry about the nature of her operation, or its ultimate outcome, some home trouble carried

into the sick-room by an indiscreet visitor, a thousand little things, may upset the delicate nervous mechanism of the patient and be the cause of a wakeful night. An *artificial* slumber produced by drugs, is not going to be of half so much benefit to such an individual as a *natural* one, following perhaps a cold sponge-bath, or a little mental influence.

The question frequently arises: How long shall we wait before catheterizing a patient after operation? In gynecological cases there is not infrequently a reflex dysuria, a reflex retention of urine which disappears after the first micturition.

Except in those cases in which the bladder had to be opened during the operation, and there is danger of leakage, there is no reason why one should order immediate catheterization. The secretion of urine after operation is naturally diminished, because the patient has lost a great deal of fluid by sweating, and, in addition, she is receiving very little to drink. It is therefore easy to understand that twenty-four hours may elapse, before the bladder is really distended to the point of discomfort, and then the patient voids spontaneously after making a slight effort. Some patients cannot void when there is someone in their presence, but are successful after the nurse has left the room; others should have a screen placed around the bed; others respond when they hear the running of the water at the hydrant; or gentle pressure over the lower part of the abdomen may start urination, or a cold application to the inside of the thigh, or water from a sponge trickling over the vulva, or gentle vibration or Faradization of the hypogastrium. It may happen that the initial difficulty is overcome after receiving an enema. Some patients, however,

Catheterization

Dysuria

defy every expedient and have to be catheterized regularly, until the moment arrives, when they are allowed to sit up; and then, voiding occurs, without any difficulty whatever. Where catheterization is necessary, it should be done as infrequently as possible; once every eight hours is, as a rule, sufficient. The vulva and meatus urethrae are rinsed with a little warm, two per cent. boric acid solution; and the catheterization is done aseptically and gently.

Record of Urine

In the first days after operation it is of importance to note the *quantity* of urine, but the specimen itself is often of little value for analysis until the first *five* days have elapsed. The reason is, that post-operative casts may appear in the urine for that length of time, and *no reliable opinion of the normal condition of the kidney can be formed from such analyses.* The analysis which tells us this, is the one made of an average specimen of urine taken *before* operation. When a routine analysis is desired after operation, the specimen should be collected *after* the fifth day. It is, of course, most accurate to obtain a sample of all the urine voided in twenty-four hours, that is, a *twenty-four hour specimen.* Where more extensive quantitative analyses are expected, this should always be done. But, in practice, it is much more convenient and ordinarily sufficiently accurate, to take equal parts of urine voided in the morning and evening, and mix the two samples to obtain, what might be called, an *average* specimen.

For a period extending from three to five days after operation, the total quantity of urine voided by the patient should be recorded by the nurse. Suppression of urine is an ocacsional cause of death after operation, and any suspicion in this

regard demands prompt and serious consideration. If the suspicion is verified, potent eliminative treatment has to be instituted, chiefly, I think, by stimulating the excretory function of the skin and the bowel surface. Hot bland drinks and a hot rectal infusion are quickly given, and the patient is packed in hot blankets until she begins to perspire profusely. This procedure, simple as it is, and old as the history of medicine, is nevertheless sometimes life-saving in its significance.

Suppression of Urine

The usefulness of drugs in such cases is limited; whether it is really an advantage to administer pilocarpine and similar diaphoretics in conjunction with the physical treatment, remains a disputed point. Some other measures, for instance, the electric light bed-baths, on the other hand, are, to my mind, frequently of invaluable service where these can be had. In some patients, at least, the relaxation which follows the active diaphoresis does not seem to be as pronounced after the electric light bath, as it is after most other sweating measures.

There are probably as many opinions on the subject of *postoperative feeding,* as there are surgeons. I have always believed in simple things, and cherished the hypothesis that nature in her inner workings is pre-eminently simple.

Postoperative Dietetics

The diet depends, in a great measure, on the condition of the stomach after narcosis. No doubt, much can be done towards minimizing the amount of nausea and vomiting after operation, by giving adequate attention to certain seemingly trifling details. There should be a proper understanding and co-operation between the anesthetist and the surgeon. If the patient receives a quarter of a grain of morphine sulphate hypodermatically, half an

hour before narcosis, the anesthetist allows by the drop method the minimum quantity of anesthetic necessary to retain the surgical plane, and regulates *carefully* the access of air to the mask to prevent, at any moment, undue concentration of the anesthetic vapors, and the symptoms which would arise from crowding the anesthetic; if the surgeon, mindful of the real welfare of his patient, is willing at times, to suffer the inconvenience of insufficient relaxation of the muscular wall of the abdomen, rather than urge on his anesthetist into crowding the anesthetic, and if he will handle the delicate structures and organs, especially the intestines, gently and as little as possible, he will have gained a great deal towards attaining this end. Some surgeons are unduly rough in their manipulations; time seems to them to be the only factor, the operation must be done quickly. But naturally, the result after such an onslaught is often to be anticipated; there is much postoperative distress, vomiting, gas-pain, and a turbulent convalescence.

Gastric Upset after Operation

Another mistake that is not infrequently made, is to *starve* the patient before operation. Withholding food for too long a period before operation, it strikes me, does not diminish, but rather helps to increase the postoperative gastric upset. The starving body is more readily poisoned by the anesthetic, than a well-nourished one. All that is required, as a rule, is that the stomach should be empty, at least it should not contain solid or coagulable food when anesthesia is induced. A stomach possessing normal mobility, should contain no food-remnants five hours after the ingestion of a meal. In the case of gastric atony, or pyloric stenosis, the stomach might have to be washed to rid it of stagnating chyme. In

Inanition before Operation

practice, when the operation is set for 8 o'clock in the morning, the patient usually gets a normal supper, consisting of digestible food, on the previous evening, and is allowed some non-coagulable drink in the early morning hours if she is awake. When the operation is to be at 2 o'clock in the afternoon, the patient gets a good breakfast, and some non-coagulable drink at 10. If the patient has not been shocked by brusque handling during the operation, nor saturated with anesthetic, she becomes conscious promptly, and soon regains her natural tone. But little nausea or vomiting is the rule, and five or six hours after operation, the nurse begins with small quantities of liquids, hot or cold, ranging from a sip to two fluid ounces.

Liquid Diet

The *liquid diet* of the patient at this period consists chiefly of water, hot or cold, weak tea, orangeade, lemonade, albumen drinks, barley-, oatmeal- or rice-water, cider and other non-intoxicating drinks. Cow's milk, is, as a rule, objectionable; it readily forms large curds and is difficult to digest; when it is allowed, it should be diluted to one-half with cereal water. The nurse begins the feeding cautiously, and with judgment; it becomes her duty to discover in each case, what agrees best with the patient. There is no rule which holds good for all. Some patients have queer idiosyncrasies. Thus, it has happened that a patient's stomach rebelled against everything, until she got the draught of Pilsener beer for which she had asked. In other cases, where the vitality is low, champagne may be given as a stimulant, and albumen drinks as a food. Sometimes a tumbler of lime-water or diluted milk of magnesia, though promptly ejected, has a sedative action on

the stomach mucous membrane, it seems, and makes it more tolerant than before.

Convalescent Diet

As soon as the patient no longer experiences difficulty in retaining liquids, generally twenty-four hours or so after operation, comes the time when she is to be started on her *convalescent diet,* excepting this is, for other reasons, contra-indicated, as in some operations on the stomach and bowel, where solid food is, for the time being, to be avoided for purely mechanical reasons. Though the patient at this time has but little appetite, she is encouraged to take food. The nurse begins, for example, with custard, or boiled rice, a piece of dry toast and tea, or an egg, soft boiled, or poached, or even a thin sandwich of scraped meat. In her selection, she caters to the patient's preference. If these agree, a piece of roast or boiled chicken, and then a chop with potato purée or milk-rice, can safely follow in the patient's menu. Excess of fats and sweets must be avoided. The stomach is easily upset by fatty foods, while sweets are objectionable because they have a tendency to impair still more the appetite, which is already diminished.

The convalescent diet to which I refer, might be correctly called a light diet, inasmuch as it includes only food which is *easily digested and does not produce a great deal of gas.* "Soft diet" is a misleading term when used, as it often is, to designate a diet for patients recovering from an operation, since it is not intended that the nurse should be guided in her seletcion of the patient's food by its *consistency;* it is the *digestibility* that she must consider. In fact, many cheeses are soft, but very hard indeed to digest, and no one would, for a moment, entertain the notion of including them in

what is ordinarily meant by a "soft diet"; the term is not significant except, if you will, in the case of an individual who is unable to masticate her food properly because she has lost her teeth.

The convalescent diet list excludes cabbage, and leguminous vegetables such as lima beans, beans, peas, lentils, because they are rather difficult to digest, and produce an excessive amount of gas. Radishes, pickles, Worcestershire sauce, mustard and much spice should be avoided. Of fruits, bananas are not well tolerated. Vinegar, that is the acetic acid in it, is very detrimental to digestion; the ordinary organic acids in fruit, citric acid in lemons for example, seem on the contrary to have a beneficial effect. For this reason may be allowed lettuce, water-cress or dandelion prepared with *lemon juice,* but not with vinegar, In fact, these leaf vegetables appear to be of certain value in supplying in acceptable combinations iron, sodium and other inorganic elements to the system; the human tissues do not consist solely of proteids, fats, carbohydrates and water. Spinach too, belongs in this category of leaf vegetables; it contains an abundance of useful iron and other salts. It is, however, essential to prepare it properly; that is, with no more water than will steam off during the cooking process. If too much water has been added, and the supernatant liquid is decanted, and poured away after cooking, most of the water-soluble salts, and other substances to which the dish owes its peculiar food value, are lost.

Cathartic Food

It is well that the diet of bed-lying patients be *cathartic* in character. The nurse can regulate the patient's bill of fare so that some cathartic food or drink is always interpolated. Fresh fruits, or

Graham bread at breakfast, or corn-crisp, shredded wheat, puffed rice, or other cereal, or stewed prunes or rhubard; or, after supper, a glass of thin buttermilk; all stimulate the sluggish peristalsis. On the other hand, constipating foods such as white bread, cake, strong tea, are restricted, or avoided altogther, as the case may be. Notwithstanding, it is the exception, especially among female postoperative cases, that does not require the aid of artificial catharsis or enemata. It is to be anticipated that a patient will tend to be more constipated in bed, than she was out of bed; the great stimulus to peristalsis given by bodily activity is wanting.

Constipating Food

After hemorrhoid operations and ano-rectal plastics, it is merely necessary to restrict the patient to a convalescent diet from which all cathartic foods have been eliminated, and the almost uniform result will be that she remains constipated for five days or longer. In view of this fact, I could never fully understand, why, in such cases, the surgeon should persist in the old routine of giving opium by mouth. Besides this, even the best of these preparations, the deodorized tincture of opium given in a little brandy, is liable to upset the irritable stomach. The patient receives morphine with discretion, but as often as she needs it to make her comfortable, just as in the case of other operations. It is always given subcutaneously, and in a sufficient dose, a quarter grain. Morphine is given hypodermatically solely as an anodyne, *not* under the impression that it has a material influence in inhibiting bowel peristalsis, as does its ally, the crude drug opium when administered in the usual dose and manner.

Furthermore, in rectal cases, there is generally not much gained by allowing the bowel to remain

Period of Enforced Constipation in Rectal Cases

inactive for a period *longer* than five days. The contents of the large bowel become so inspissated and desiccated, that ultimately their evacuation is accompanied by considerable mechanical difficulty, and perhaps damage to the site of operation. Indeed in these cases, there is less probability of damaging the suture-line on the fourth or fifth day, than later, when the "40- 60-day" catgut begins to dissolve. The only reason for binding the bowels, is in order to keep the anorectal wound or suture-line clean, until at least a superficial protective healing has taken place, and infection is unlikely. This is surely the case after five days have elapsed. In fact, if the wound-lips of the rectal mucosa are apposed with nicety, and this can be best done by using a submucous suture of fine chromic catgut, 000 to 0 in size, and "40- 60-day" resistance, the wound is superficially, but sufficiently sealed within a few days to protect it quite well from subsequent infection, especially if the bowel movements have been loose. After the fifth day, the bowel evacuation should be anticipated by an oil and soap suds enema given through a well lubricated soft rubber rectal tube. The anal and rectal mucosa covered with an oily layer, is less liable to be damaged during the act of defecation.

Drugs for Postoperative Catharsis

The ideal cathartic to be given by mouth for postoperative use, would be one which is not disagreeable to take, and which produces a fluid movement with the least amount of griping and distress to the patient. Castor oil, though most children do not object to taking it, especially if sweetened with syrup or honey, is nevertheless a potion to which few adults take kindly. To an adult, it might how-

ever be given in the historic form, the castor-oil sandwich.

Rp.

Sirupi Rubi Idaei	fl. ℥ij
Glycerini	fl. ℥j
Olei ricini	fl. ℥vij
Spiritus frumenti	
or Spiritus Vini Gallici	fl. ℥ij

D. Pour carefully into a graduated medicine glass in the order given. The fluids will produce four distinct layers. But at best, it is a bulky dose, and its extemporaneous preparation is too complicated.

Formulae

An attempt of mine, to avoid these objections, resulted in the use, for a time, of the following prescription:

Rp.

Olei tiglii c.p.	mxvj.
Olei ricini	
Alcoholis absoluti āā	fl. ℥ss
Olei foeniculi	
Olei myristicae āā	mxxx

D. S. Average dose, fifteen drops in a little brandy. Maximum dose, thirty drops.

In this combination, the potency of the oleum tiglii is not lost, but its griping effect is reduced to a minimum. The cathartic is very prompt and effectual in its action. The *drastic effects* of croton-oil administered in the undiluted state, such as blood in the dejecta, I have never observed, even with doses of half a fluid drachm. An objection to the

general use of such a cathartic, however, is the fact that it has to be given in an alcoholic medium. Taken in milk, it seems, that at times, its cathartic action is impaired.

In the long run, it is *calomel* still, that is perhaps the most serviceable, for the postoperative, just as in the preoperative routine. It is not the simple stimulation of an after-dinner pill, but prompt and reliable evacuation of the bowel which is here most often demanded. The calomel should be administered in a *single dose of three grains* to the adult, exceptionally two grains. It is a mistake to give it in divided doses for this purpose. Given in divided doses, calomel is more prone to produce emesis when the stomach is irritable; more of the mercury is absorbed, and salivation results more easily.

In the rectal case, after the first evacuation of the bowel, the chief difficulty is passed. The nurse sees to it that the patient's diet now becomes cathartic in character in order to stimulate the bowel naturally, and in order to preclude constipated movements. After the ordinary laparotomy, or for that matter, after perineal operations as well, in which *the rectum is not involved,* an evacuative enema of plain water or of 1 per cent. soap suds is ordered after the third day. There is no serious objection to giving such an enema earlier, if the indication should arise. Not uncommonly, on the day following operation, a low peppermint enema, for instance, is administered to facilitate the expulsion of gas which distends the bowel unduly.

Enemata

The evacuative enema besides freeing the large bowel of its stagnating contents, aids in inciting more active peristalsis in higher portions of the gut,

and thus promotes the expulsion of gas which makes the patient uncomfortable.

Mild Catharsis

After the ordinary laparotomy, cathartics by mouth, when given—generally on the fifth day—can be milder and more varied than in rectal cases where the bowel has been kept inactive. The patient here may even indicate the cathartic which she thinks agrees with her the best, and which she has been in the habit of using. A little magnesium citrate, or the aromatic fluid extract of cascara sagrada, or, a simple extract of cascara sagrada pill which contains no harmful ingredients, is not objectionable.

Normal Full Diet

The transition to a rational *full diet* ought to be made when the short period of gas-pain is passed, the habitual bowel activity restored, the temperature is approaching the normal, and there need no longer be any serious scruple about readily upsetting the patient's digestion by granting her more latitude in her meals. Its greater variety adds a healthy natural stimulus to the patient's appetite and digestion. While it does not overtax the patient's digestive powers, it demands the exercise of the normal digestive function. The normal full diet which is least inimical to the digestive and eliminative organs of the human adult, is not one, it seems to me, consisting largely of meats, nor is it a strictly vegetarian diet, as others would have it. I have myself, for the sake of experiment, lived as a fairly strict vegetarian for a period of five years (1895-1900), and although the term is too short to allow me to draw many conclusions as to the effect produced in the human system by excluding animal food, I feel warranted in saying that purely vegetable food, although correctly prepared in a good

kitchen, calls for a digestive energy which most of us do not naturally possess, and which is not readily developed even after a number of years of vegetarianism. Also animals like the dog can be fed, and can exist on vegetable food, but it seems here too, the digestive organs are not quite equal to their task. A healthy English greyhound pup was restricted to a vegetable diet, from which all meat was excluded, for a period of three years; the animal relished his food, grew and appeared at first to develop normally, but later signs of subnormal nutrition began to become evident, his hair grew dry and glossless, the musculature somewhat thin, though of good quality, panniculus adiposus scanty so that the outline of the ribs was pronounced. Unfortunately, I cannot record the corrective influence of a change in the animal's food. Some hardened wretch, soon thereafter, poisoned with strychnia, my mute companion in this little study in vegetarianism.

Vegetarianism

The normal full diet for a postoperative case, should not be an extreme diet; it should be a *mixed diet* in which flesh food is allowed moderately, once a day, or, in smaller quantities twice a day, certainly not oftener. The proper cooking of vegetables is a lost art, and as a consequence perhaps, the average individual eats too much meat. The constipated bowel with fluids stagnating in the caecum and appendix, and the torpid liver would, no doubt, be helped by the cathartic influence of *more* vegetable food.

Excess of Flesh Food

While aiming to put the patient on the normal full diet as soon as this is feasible, in most cases from the fourth to the seventh day after operation, a few cannot be subjected to such a rapid

transition, and may have to remain on a carefully supervised, selected convalescent diet throughout the entire period of their recovery. Occasionally one meets with such a patient, who begins to eat and digest properly the moment she is up out of bed.

Changes of Position after Operation

With few exceptions, the laparotomy case may be placed on her side on the first or second day after operation. Of course, if she is a very adipose woman with an abdomen which overflows the iliac crests, it is wiser to keep her on her back during the entire postoperative period. After a few days such patients begin to become used to this position, and do not feel the restriction as they did at first. After operations on the female perineum, the lateral posture enables the wound to be kept dry by allowing the accumulating discharge to gravitate away from the suture line—this point, I think, is vital in obtaining successful union in complete tears of the female perineum. In inguinal or femoral hernioplasties, a lesson is to be learned from children who are wont to lie on the operated side—evidently the position of comfort. Under ordinary conditions there need be no hesitancy in permitting this in the case of adults, except where an operation for hernia has been done on *both sides*. It should be our endeavor to see how admirably nature often points out the way to us, if we will but study her with a little insight. A sad spectacle is he who looks for therapeutic indications only in books, and neglects to discover them in his patients.

The patient's second week—*the week of waiting*—should, to the fullest extent, be made available for her mental and physical rehabilitation. During the day her mind is kept occupied, to prevent undue introspection and brooding. Wire puzzles, Japanese

The Second Week

puzzles with complicated dove-tailing, engage the hands and brain, or brass-punching, or modeling in artist's clay, or folding gauze for the operating-room, are all better than fine needle-work or much reading. A male patient may derive considerable pleasure from a cigar, it is not encouraged but allowed; while another with a constructive bent, begins to while away his time by whittling some chess figures, or a wooden chain. It is sometimes necessary to discriminate between visitors. Members of the family or friends with a cheerful disposition are desirable, and may help to modify the patient's mood.

Methods of Retaining the Dressing

After gynecological operations where the median vertical, the mesial rectus, or the semilunar hypogastric incision is used, the lower border of the dressing is secured by means of a strip of zinc oxide adhesive two inches wide, before the patient is taken from the operating-room. The strip reaches from the outside of one hip, to the outside of the opposite one. It overlaps the dressing, about three-quarters of an inch below, where it is made to adhere firmly to the symphysis, immediately above the vulvar incisure. Sponging the area with a little ether or liquor expurgans, aids materially in obtaining good adhesion of the plaster. An oblique incision of about one inch, in the direction of each inguinal fold, makes possible better adaptation, and prevents the plaster from being pulled or lifted away from the symphysis so readily when the thighs are flexed. Laparotomy straps consisting of strips of adhesive plaster one inch in width with tapes attached, two or three on each side of the abdomen, are tied over the dressing to keep it in place. In their stead, a single wide piece of adhesive on each side, lined with

rubber tissue, or with a single layer of gauze where it touches the dressing, can be laced in front in the manner of a corset. Nevertheless, in either case, it is well not to discard the traditional plain, or many tailed binder which affords additional support and protection to the wound. In very fat subjects with a large incision, the wound is not supported sufficiently, even with a snugly applied binder, and it is safer to *encircle* the abdomen with broad (four inch) strips of zinc oxide plaster beginning below and allowing each tour, to be overlapped partly by the next, while the ends cross each other in front obliquely, over the dressing. I have had occasion to regret my neglect to observe this precaution, in a rather adipose patient in whom, on account of the magnitude of the pelvic tumor, a large incision was necessary. During a violent coughing spell, the entire suture-line was burst open, allowing the intestines, partly covered by the omentum, to escape into the grasp of the dressing. Although the suture had been carefully done by layers, the catgut had *cut through* the friable tissues, each knot still remaining securely tied. In the case of an inguinal or femoral hernia, the best support is given by a firmly applied spica. The bandage should be not less than four inches wide for the adult, and the bony prominences padded with non-absorbent cotton. In most cases it is indicated to reenforce the bandage with a single figure-of-eight tour of adhesive plaster.

The First Dressing

Unless there has been some complication in the normal wound-healing, the first dressing is not due until the fifth, sixth or seventh day after operation. In laparotomies dressed in the manner described, it is merely necessary, after undoing the tape of the straps or adhesive corset, to reflect the dressing

downward over the pubes, when the suture line comes to view. If there is no redness or moisture about the stitches, no tender infiltration to the touch, the wound has healed by primary intention. Indeed, that is what is to be expected if the postoperative temperature chart shows no deviation from the normal aseptic reaction. If absorbable material has been used for suturing the skin, the patient learns with satisfaction, that contrary to her expectation, no sutures have to be removed. Michel's skin clamps call for an early dressing, generally on the fifth day. In case adhesive strips have been used for skin-closure, early dressing is not vital. Silkworm gut sutures at the angle of a secreting or discharging wound, or in flaps which are under tension, as after radical operations for cancer of the breast, or in the perineum, had better be left until the twelfth day. Silver leaf cut into small squares and sterilized in packets of a dozen or more, between two squares of thin wood (J. S. Lewis), has occasionally been used to cover the suture-line immediately after operation, in order to prevent the gauze dressing from adhering to it. At the first dressing the silver leaf is found more or less minutely pulverized, and where there is oozing from the incision, it tends to create an undesirable crust.

Drains

The removal of drains of rubber tissue or tubing from aseptic wounds where there is much oozing, is occasionally necessary. Thus after the radical operation for cancer of the breast, drainage of the axilla for 24-48 hours is required to remove the accumulating lymph, and this necessitates an early dressing. At one time drainage was almost a routine after the ordinary hernioplasty. In this case the pressure exerted upon the wound dressing when

the bandage is properly applied, ought to be sufficient to prevent the accumulation of much lymph or blood. Much depends upon the proper application of the spica. In obese individuals difficulty in this regard is obviated, by obliterating the gaping spaces in the subcutaneous fat at the time of the operation, by means of a thin absorbable suture. It is surely better, to attend to such details with proper precision while the patient is under the anesthetic, than to be encumbered later at the dressing by complications which might have been avoided, and then attempt to make good a neglect.

Where reasonable care and circumspection have been exercised at the operation, the postoperative treatment usually becomes a simple matter as far as the surgeon is concerned. The routine first dressing on the fifth, sixth or seventh day after operation includes the removal of skin sutures or clamps or, when an absorbable skin suture was employed, consists in little more than an inspection of the wound, and the substitution of a new piece of sterile gauze for the one which has been in contact with the incision.

In gynecological cases the protective gauze pad which was reflected for the dressing, is returned to its place, and the laparotomy straps or corset flaps are fastened over it, as before. Only at the second, that is the last dressing, the entire adhesive support is removed, and the skin freed from the adherent zinc oxide by means of benzine, ether, or liquor expurgans. If there happens to be a point in the wound where the apposition was not good and healing was delayed, a tiny bit of sterile gauze and a small strip of adhesive, are all the dressing requires. The area where the plaster has been, is thoroughly

Temporary Support after Operation

powdered by the nurse. A supporting belt need rarely be ordered. The so-called "straight front" corsets which are now in vogue, are constructed on sounder principles than the old-fashioned type; the abdomen is lifted from below upward, and adequate support is given to the young and distensible scar. A corset of neat pattern has been constructed which consists of two pieces, one shifting over the other, and which allows more freedom in bending the body forward. It is well adapted to the needs of corpulent patients with a pendulous abdomen, who are otherwise difficult to fit properly. The nurse instructs the patient to apply the corset in the recumbent posture, and to lace it always from below upward. Cases of inguinal or femoral herniоplasty leave the hospital wearing as a temporary support of the recently healed wound, a tightly wound spica. This is reapplied once more as soon as it loosens, which is usually in the course of a week.

The question, "When shall the patient be allowed out of bed after an aseptic laparotomy?" has evoked diverging opinions. Some surgeons lay little stress on the stretching of the scar, and the possibility of a postoperative hernia. But it seems unfair to the patient to disregard these factors, and better to *retain the average aseptic laparotomy in the recumbent position for not less than twelve days.* In the case of a fat individual with poor healing power, an additional week is not superfluous. To keep a patient in the horizontal plane of her bed, does not necessarily imply that she should be immobile. The use of the extremities and changes of posture, promote the venous return and are helpful, rather than detrimental, so long as no strain is put upon the

When may the Patient Sit Up in Bed?

incision. Cavil none will, that the patient *can* be gotten up almost any day after operation, but the salient point at issue is not what can be done, but what is most adequate if the patient's *future* welfare is considered. Indeed, for that matter, it might be safer to allow a patient to sit up on the third day after an abdominal section, than on the sixth or seventh, when the stitches begin to be dissolved.

By far the greater number of laparotomies are uncomplicated in their recovery, and can be discharged from the hospital on the fourteenth day of their stay. On the morning of the day before dismissal, the patient for the first time assumes the vertical position, she is permitted to sit up in bed. Some patients, particularly anemic ones, are inclined to become dizzy during this first attempt, and a hot, exhilarating drink may be given as a prophylactic measure. In the afternoon, the patient is allowed to sit in a chair. On the morning of the last day, a final revision of her condition is made. She will, by this time, have partly reaccustomed herself to be up and about, and is prepared for the event of her departure.

Report to the Family Physician

As soon as the patient is dismissed from the surgeon's care, important data and details concerning her condition should be transmitted to the family physician or specialist into whose hands she reverts. It is an attention due the patient, as well as the physician who has to take further charge of her, and now becomes responsible. Perhaps some of the problems concerning the proper ethics to be observed between physician and surgeon regarding the transfer of a case, may become very much simplified, if both truly agree that the *patient's best interest* should determine their course.

CHAPTER XII

The Interpretation of Post-Operative Fever in Aseptic Cases

It is a matter of common knowledge, that every operation on an aseptic case is physiologically followed by a slight rise in temperature, which is *not due to infection.* The rise in temperature is so definite and uniform in its behavior, that the conception of a *typical aseptic wave* seems well founded. Naturally, the normal reaction is most evident in cases with a strictly *uncomplicated* recovery. In practice, such cases are the exception, and there is therefore usually imperative, a more critical analysis of the post-operative fever-curve, in order to distinguish the general trend of the fundamental reaction, from that which is incidental, and due to some complicating factor.

Aseptic Fever

But what are the essential characteristics of the typical aseptic reaction? The problem may be approached directly by eliminating at once, from this study, all pus cases, in fact, all cases which have not a normal temperature before operation. As a matter of course, a correct picture of the aseptic reaction can only be expected in a case which is primarily aseptic, and in which even the minor details of asepsis during operation have been watched with particular scrutiny.

As a result of such an attempt to define the aseptic reaction, the following deductions may be recorded:

(1) The mean daily *rectal temperature* is normally about 99.1° F. The daily fluctuation is approximately 0.6° F. That is, the highest normal reached during the day is 99.4° F.; the lowest is 98.8° F. (Illustrated in Table I).

(2) The mean daily *oral temperature* is normally about 98.4° F., that is, about 0.7° F., or a little more than half a degree lower than the mean rectal temperature. The oral temperature varies more widely than the rectal; approximately 0.8° F., the minimum being 98° F., and the maximum about 98.8° F. under normal conditions.

Data

(3) The difference between rectal and oral temperature *does not remain constant* in the same patient, as the temperature rises. It is not accurate to compute from the fever-curve, obtained by recording the mouth temperature, the corresponding rectal, or vice versa, by adding or subtracting a constant factor. (Illustrated in Table II.)

(4) The *temperature obtained in the proximity of the surgical lesion,* represents more nearly the true reaction, than that obtained at some remote part of the body. When the pelvic or abdominal organs are concerned, as in gynecological operations, and the greater number of operations in general surgery, the excursions of temperature are more correctly indicated by the rectal, than by the oral reading. (Illustrated in Table III.)

(5) There is normally a slight post-operative temperature rise which is not traceable to infection —the *aseptic fever.*

(6) The *maximum rise or acme* in the normal post-operative curve of aseptic cases, may occur as early as 4 hours, and as late as 33 hours after operation, without being pathognomonic. The computed *average time* in one series of cases was 18 hours. (Table IV.) As a rule, the maximum rise is reached *within* 24 or 36 hours—a day, or a day and a half after operation.

(7) The *average maximum rise* is about 100.6° F., and should not exceed 101° F., rectal temperature. (Illustrated in Table IV.)

(8) The *time of day* during which the operation is done has a slight, though neither a uniform nor vital bearing on the post-operative reading.

Data

(9) The maximum rise or acme may be *more or less acute,* followed at once by a remission, and this is the rule; or, very rarely, the wave may have a plateau-like summit; exceptionally in such event, the same temperature may persist without any appreciable remission, as long as nine hours.

(10) There is normally a well defined second rise, a *post-maximal rise,* on the day following the maximum rise, but *it should never exceed the former in amplitude unless there is some complicating factor.*

(11) Exceptionally a small abortive wave—a *pre-maximal wave*—may immediately precede the maximum rise. This should not lead to confusion in interpreting the temperature chart.

(12) In general, in the wholly uncomplicated case, the temperature waves on successive days may

be expected to show *a gradual subsidence in amplitude;* and reach the normal, in the course of five days, or at the end of a week.

(13) The daily average temperature, or *mean temperature, towards the end of the second week* after operation, is apt to be a little lower, than that obtained for the same patient before operation. Thus, it is, at the end of the second week, about 98.7° F. by rectum (Table V), and about 98.2° F. by mouth (Table II.)

(14) *In taking oral temperature, the sources of error are greater,* and the individual variations in temperature less pronounced so that they may be overlooked altogether. Oral readings do not represent the actual magnitude of the reaction, when a celiotomy is in question. They do not offer a very satisfactory basis for study.

The Schematic Curve

Utilizing these findings the characteristic reaction which follows operations on aseptic cases, *the aseptic fever-wave* may be represented graphically and schematically (Chart I).

As soon as the theory that a typical curve represents the aseptic reaction following clean operations, can be considered established, *it becomes a simple matter of bedside study to discover the meaning of anomalous fluctuations.* Indeed, every departure from the typical aseptic wave, requires its interpretation. On the one hand, must be considered deviations representing minor complications which are of no grave import, as for instance, stagnation in the bowel, or onset of menstruation in cases with an old pelvic trouble, a bronchial catarrh, and even

a superficial wound-infection; on the other hand, those which are the expression of serious complications, such as a deep wound-infection, peritonitis or sepsis. This conception at once enhances the clinical significance of the temperature record, and suggests a way to the more intelligent reading of it, on the part of the surgeon.

Actual Curve of Aseptic Fever

To begin with, it seems best to select, for the sake of illustration, an actual case (Chart II), which demonstrates the normal course of aseptic fever, and embodies all the points already emphasized in the schematic representation of the aseptic wave. Here aberrations in the temperature, which are due to infection, bowel stasis, or other minor complications are absent.

By all odds, the most frequent source of slight, or even marked disturbance in the normal reaction after operation, is stagnation in the bowel. Because the period of constipation is at first too brief, the maximum rise itself need not be influenced at all. But indicative, is a slight rise on the fourth or fifth day, which can be promptly corrected by the enema or calomel.

Effect of Bowel Stasis

This rise may sometimes, however, appear a little earlier, and become alarming on account of its height, especially where the stasis is pronounced, as when the patient's bowel has not been properly evacuated *before* operation. A chart which illustrates this point, is that of a patient, in whom, contrary to the rule, home preparation of the bowel was relied upon (Private Record No. 2301, N. P., 1909). The temperature rose to 104.4° F. per rectum on the third and fifth days; the pulse

rate, which was normally 76 to 78, however, remained comparatively slow, varying only between 100 and 106 per minute during this time, and the respiration from 22 to 28. After a very effectual washing of the bowel the temperature dropped to the normal. There was no tenderness, infiltration or hematoma, no redness or secretion about the incision, which was found healed by primary intention on the sixth day. It seemed clear that the bowel alone, was responsible for this anomalous reaction. (Chart III.)

Influence of Menstruation

In some instances, in female patients, a slight rise of temperature occurs, accompanied perhaps by a few nervous symptoms, a sensation of weight and discomfort in the pelvis, and feeble recurrent pain in the back occasionally radiating into the thighs. The disturbance cannot be traced to the condition of the bowel, and may remain obscure, until a few days later, when the nurse reports that the patient is menstruating. The rise probably appeared coincident with the pelvic vascular hypertension which may precede the actual appearance of the menstrual blood by one or two days. But it does not seem entirely correct to ascribe it to the *physiological menstruation.* Under strictly normal conditions of the pelvic organs, there should be no secondary rise —post-maximal rise—ascribable to menstrual pyrexia, which exceeds the maximum rise in amplitude. A number of observations speak for the assumption that when such a rise occurs, it points to an old iflammatory, toxin-producing focus somewhere in the pelvis, which is not completely healed, and the temperature can be explained by the in-

creased absorption incident upon the menstrual cycle. It may be a chronic salpingitis for example, which presents no appreciable temperature rise during the intermenstrual period, but shows a distinct "absorption rise" with every oncoming menstruation. (Chart IV.)

The assumption, that in the absence of pelvic inflammation, menstruation itself does not materially modify the typical temperature, is strengthened by the fact that operations performed during the period of menstruation show essentially the same maximum rise, as those done in the intermenstrual time. Thus, for example, after enucleating a number of uterine fibroids, and removing the appendix in a young woman on the fourth day of her menstruation, she continued to menstruate for three days after operation. On the one hand, the inaugurated flow was not interrupted by the surgical measure; on the other, as reference to the patient's previous history shows, its duration was not changed. The operation occurring on the fourth day was exactly midmenstrual in time. Notwithstanding this fact, the postoperative reaction was practically the same as that obtained in other cases operated *between* periods. The rectal temperature fluctuated between 98.4° F. —99.4° F. in the twenty-four hours preceding operation. That is, the mean daily temperature was 98.9° F. The maximum rise was reached in twenty-nine hours after operation. It was 101° F. The second rise—post-maximal rise—on the third day, reached 100.2° F., and on the fourth day the acme was 99.8° F. (P. R. No. 3429, C. V.)

Operation During the Menstrual Period

Before concluding that a fluctuation in temperature is anomalous, it is not to be forgotten that

secondary rises occur on the days following operation, but that a complicating factor is to be thought of only when these *exceed* the primary one.

There is another point of interest in the temperature curve of this patient. Although the menstruation had ceased, and there was no bowel stasis, there was a rise to 100.4° F. on the fifth day, another to 100.6° F. on the sixth, 100.4° F. on the seventh, then 99.8° F., followed by a subsidence to the normal. As soon became evident, this slight pyrexia had its origin in the wound. It represented one of the mild skin infections, in which a tiny focus promptly drains itself on the surface. Similar perturbations occur not infrequently in vaginal operations, or other operations involving the mucous membrane, where it is difficult to obtain satisfactory surface sterility.

Influence of a Mild Skin Infection

Such mild wound infections as these cause no marked constitutional distrubance and very likely often escape notice, but there are others which must still be classed as belonging to the group of minor complications, although they present a more elaborate clinical picture. In these severer cases, the existence of the local infection may be indicated by some aberration in the temperature very soon after operation; nevertheless a pronounced rise—102° F. or 103° F.—accompanied by notable systemic disturbances and symptoms referable to the wound, is never likely to occur until the sixth or seventh day. In other words, allowance must be made for a definite period of incubation. The pulse rate and respiration, just as in many other comparatively innocent complications, do not keep pace with the excursions of the fever. To amplify these points

More Marked Skin Infections

reference might be made to the post-operative behavior of a case, in which beyond all reasonable doubt, the contamination of the wound had its origin in the follicular and glandular skin of the pubic region. (Chart VI.)

In this chart, for clinical reasons, but unhappily for numerical comparison with the preceding ones, the mouth temperature only is recorded. The pre-operative temperature showed a daily fluctuation between 97.2° F. and 98.6° F. per os. The pulse ranged from 66 to 72, and the average frequency of respiration was 20. The operation was done at ten o'clock in the morning, and up to thirty-four hours after it, the record of temperature was as follows:

Case Illustrating the Effect of a Marked Skin Infection

6	hours p. o.	100.2°	F. oral	
10	" " "	100.4°	"	
14	" " "	100.8°	"	P. 86 R. 20
18	" " "	100.2°	"	
22	" " "	99.6°	"	
26	" " "	99.4°	"	
30	" " "	99.4°	"	
34	" " "	101.2°	"	P. 76 R. 20

Here the primary or maximum rise is at midnight of the day of the operation, and twenty hours later there is a second rise, which is greater than the first, and is to be considered abnormal. There were at the time *no subjective symptoms whatever to lead to the suspicion of a future complication in wound-healing.* A few days after operation, however, the profuse sweating of the patient attracted attention, notwithstanding that the summer was exceptionally warm; but there was no complaint of pain in the region of the wound until the fourth

day. On the day following this, there were experienced indefinite shifting pains in the neck, knee, wrist and arm, unaccompanied by any swelling of the joints. The pains became more pronounced on the sixth day, when the remittent temperature reached its acme with 103.2° F. per os. Nevertheless the pulse remained relatively slow, and the heart action normal. The first impression of these symptoms was quite misleading. Typhoid fever or malaria could readily be differentiated, but with much less certainty an atypical articular rheumatism, in its onset. The lower border of the spleen was not palpable, but the organ measured three inches in the axillary vertical. The blood examination showed

The White Cell Count

White cells	18,400
Polymorphnuclear neutrophiles	91.5%
Small lymphocytes	5.5%
Large lymphocytes	1.0%
Eosinophiles	2.0%

No plasmodia; Widal reaction negative.

A faint redness of the wound-line at first, was succeeded after the sixth day by a separation of the wound near its middle, to the extent of about half an inch, with the discharge of a small quantity of odorless pus. After this free drainage the temperature gradually subsided, and on the thirteenth day the little granulating gap which reached to the surface of the external oblique aponeurosis, was closed by apposing the wound-lips, and applying sterile zinc oxide strips. The temperature continued to remain normal.

In analyzing the effect of the various minor complications, intercurrent ailments of slight severity must also be borne in mind. Exceptionally a "catarrhal fever," "la grippe" or "influenza nostras," as the condition has been variously called, may explain an anomaly in the post-operative reaction. Illustrative of this is the temperature of a patient, on whom an abdominal plastic had to be done for a post-operative ventral hernia, a sequel of the old method of treating cases of pyosalpinx by suprapubic drainage. (Chart VII.)

Effect of a Cold

In the primary rise, which persists from the ninth to the eighteenth hour after operation, the thermometer registers 100.6° F. per rectum. This in itself need not be considered abnormal. But the second rise on the third day was 100.8° F., that is, apparently *greater* than the primary rise, and the aberration, with proper reserve because of the slightness of the difference, is taken to indicate some foreign influence. The recurrence of a rise of 100.8° F. on the fifth day is however clearly pathological, and the slight pain in the chest, cough and mucous expectoration at this time, explained its source. The usual causes of fluctuations in the typical curve, were absent. There was no tenderness over the wound-line; no bowel stasis. On the seventh day the temperature reached 102° F. The daily excursion in temperature was from 100.4° F. to 102° F. per rectum. The pulse rate varied between 80 and 108. The cough continued. Examination of the chest showed the typical signs of a catarrhal bronchitis. The variation of the fever on the eighth day was from 101° F. to 101.8° F., and the pulse frequency from 100 to 104. The sputum became greenish in color, and was moderate in

quantity. The râles diminished. The next day the temperature dropped from its maximum of 100.2° F. to 99° F. The highest wave was 100° F. on the tenth, and 99.6° F. on the eleventh day, and with the subsidence of the temperature, the cough also disappeared. There can be little question, that the moderate pyrexia was due to an ordinary influenza nostras, of which the catarrhal bronchitis was part and parcel.

Major Complications

Finally, with a clear impression of the nature and behavior of the aseptic reaction in the uncomplicated case, and of its modifications by minor complications, *the way is open to the further study of the influences which more serious complications may exert.*

In this exposition, I have yielded to the temptation to present a theory, *incomplete as it is, and still insufficiently founded.* In its application, it should not be overlooked, that it must needs be restricted to those cases which were aseptic and afebrile at the time of operation. With the proper reserve imposed upon it by the cautious worker, it may perhaps be of use, but it would be unscientific and misleading to extend its scope unduly.

Table I.

MEAN DAILY RECTAL TEMPERATURES. PRE-OPERATIVE.

Case.	Minimum.	Maximum.	Mean.
P. R. 3429 C. V.	98.6° F.	99.4° F.	99.0° F.
P. R. 3003 T. R.	99.2° F.	99.8° F.	99.5° F.
P. R. 2010 L. M.	98.8° F.	99.0° F.	98.9° F.
P. R. 3385 P. L. S.	98.8° F.	99.4° F.	99.1° F.
P. R. 3228 C. W.	98.4° F.	99.6° F.	99.0° F.
Average	98.8° F.	99.4° F.	99.1° F.

Table II.

DAILY MEAN TEMPERATURE IN ASEPTIC LAPAROTOMY. RECTAL AND ORAL TEMPERATURES COMPARED.

	Pre-operative Temperature.	Maximum Rise.	P.O.Temp. 2nd week.
Rectal temperature	99.1° F.	100.6° F.	98.7° F.
Oral temperature	98.4° F.	100.3° F.	98.2° F.
Difference	0.7° F.	0.3° F.	0.5° F.

Table III.

RECTAL AND MOUTH TEMPERATURES IN THE SAME PATIENT TAKEN SIMULTANEOUSLY NEAR THE END OF THE FIRST WEEK AFTER HYSTERECTOMY.

P.R. 4558 E.K.	Per rectum.	Per os.	Differeence.
12 noon.	100.0° F.	99.0° F.	1.0° F.
4 P. M.	99.8° F.	99.0° F.	0.8° F.
8 P. M.	100.2° F.	99.2° F.	1.0° F.

Tables

Table IV.

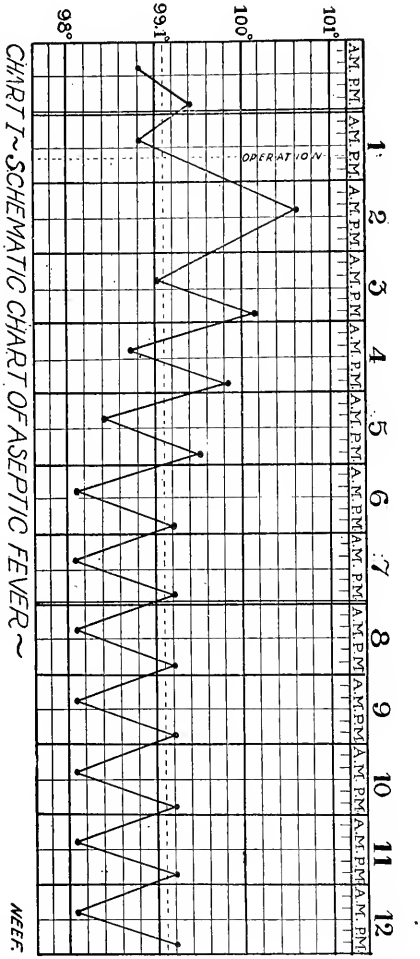
THE MAXIMUM RISE AND THE TIME OF ITS APPEARANCE. RECTAL TEMPERATURE.

Case.	Time of Operation.	Maximum Rise.	Number of Hours after Operation.
P. R. 3429 C. V.	3 P. M.	101.0° F.	29
P. R. 2966 K. H.	9 P. M.	100.4° F.	12
P. R. 3385 P. L. S.	3 P. M.	100.6° F.	29
P. R. 2010 L.M.	3 P. M.	100.4° F.	9
P. R. 2790 L. M.	3 P. M.	100.4° F.	21
P. R. 695 S. S.	3 P. M.	100.6° F.	9
P. R. 2360 J. T.	3 P. M.	101.0° F.	13
P. R. 2301 N. P.	10 A. M.	100.8° F.	21
Average		100.6° F.	18

Table V.

MEAN DAILY RECTAL TEMPERATURE, SECOND WEEK POST-OPERATIVE.

Case.	Minimum.	Maximum.	Mean.
P. R. 3429 C. V.	98.0° F.	99.4° F.	98.7° F.
P. R. 2966 K. H.	98.0° F.	99.4° F.	98.7° F.
P. R. 3003 T. R.	98.4° F.	99.0° F.	98.7° F.
P. R. 2010 L. M.	98.2° F.	99.4° F.	98.8° F.
P. R. 2790 L. M.	98.0° F.	98.8° F.	98.4° F.
P. R. 2360 J. T.	98.2° F.	99.4° F.	98.8° F.
Average	98.1° F.	99.2° F.	98.7° F.


101°
100°
99.1°
98°
A.M. P.M.
OPERATION
1 2 3 4 5 6 7 8 9 10 11 12
CHART I~SCHEMATIC CHART OF ASEPTIC FEVER~
WEEK

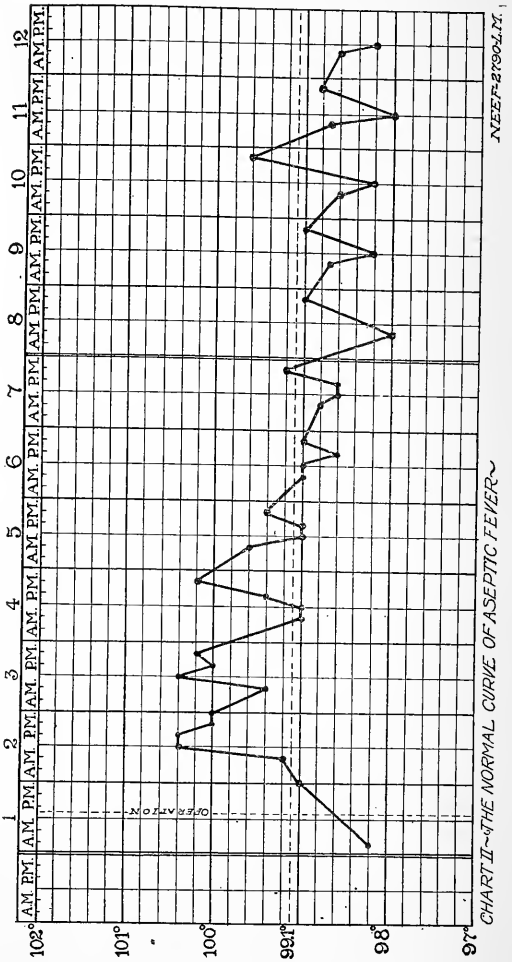
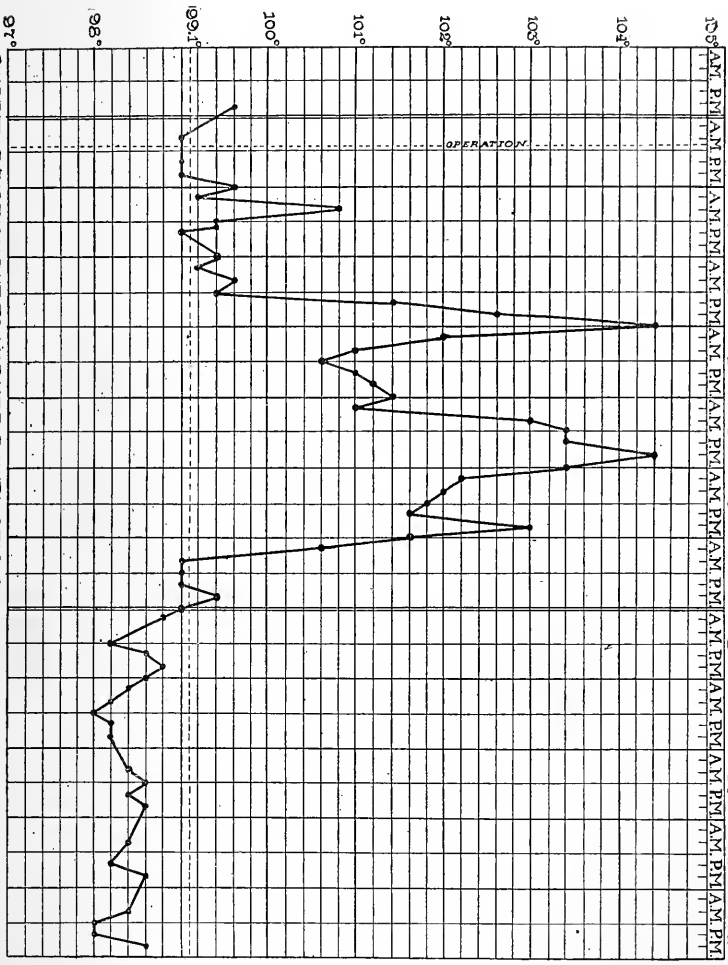


CHART II—THE NORMAL CURVE OF ASEPTIC FEVER


105°
104°
103°
102°
101°
100°
99.1°
98°
97°
A.M. P.M.
1 2 3 4 5 6 7 8 9 10 11 12
OPERATION
CHART III~REACTION DUE TO MARKED BOWEL STASIS~
NEER-230-NP

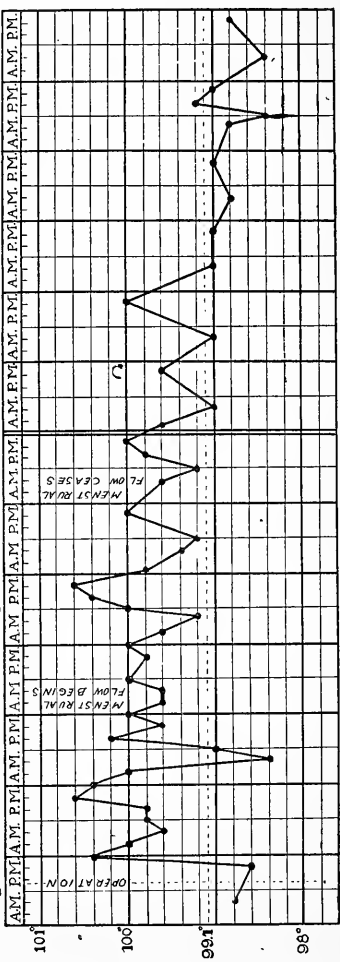


CHART IV~P.O. MENSTRUAL RISE IN A CASE OF RETROVERSIO-FLEXIO UTERI. NEEF~2010~L.M.

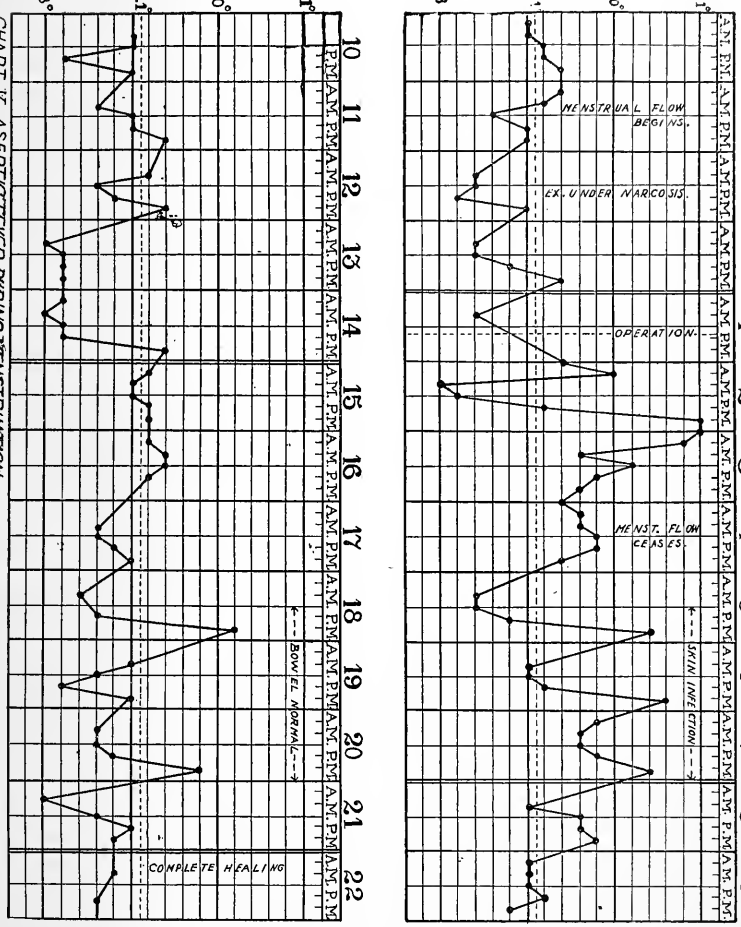


CHART V—ASEPTIC FEVER DURING MENSTRUATION

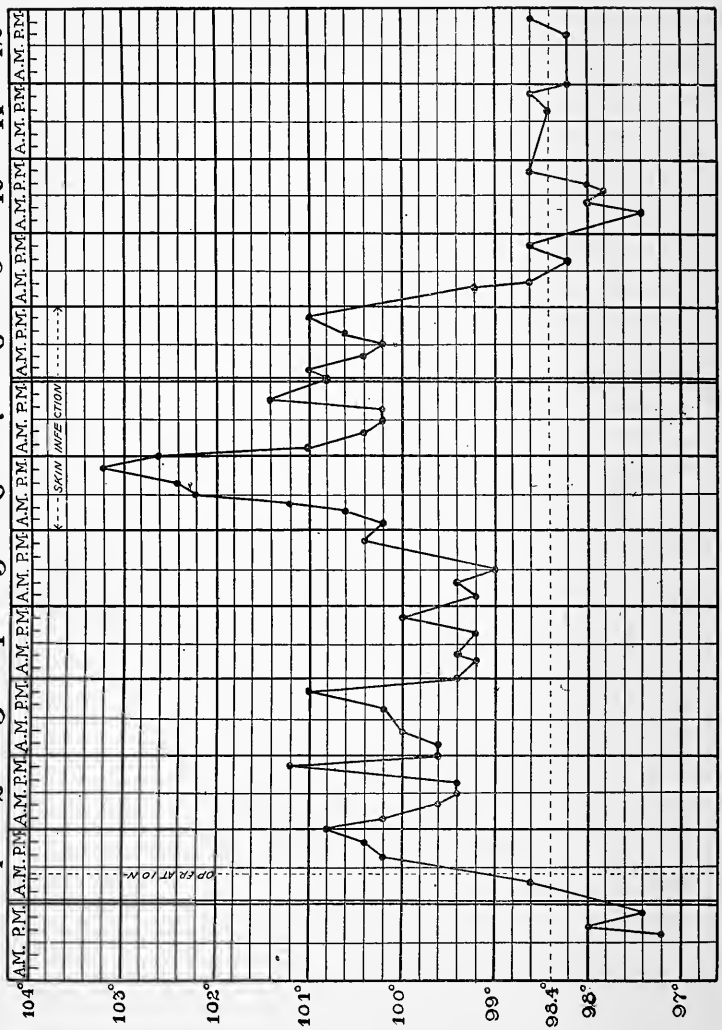


CHART III ~ P.O. FEVER CURVE IN A SKIN INFECTION ~

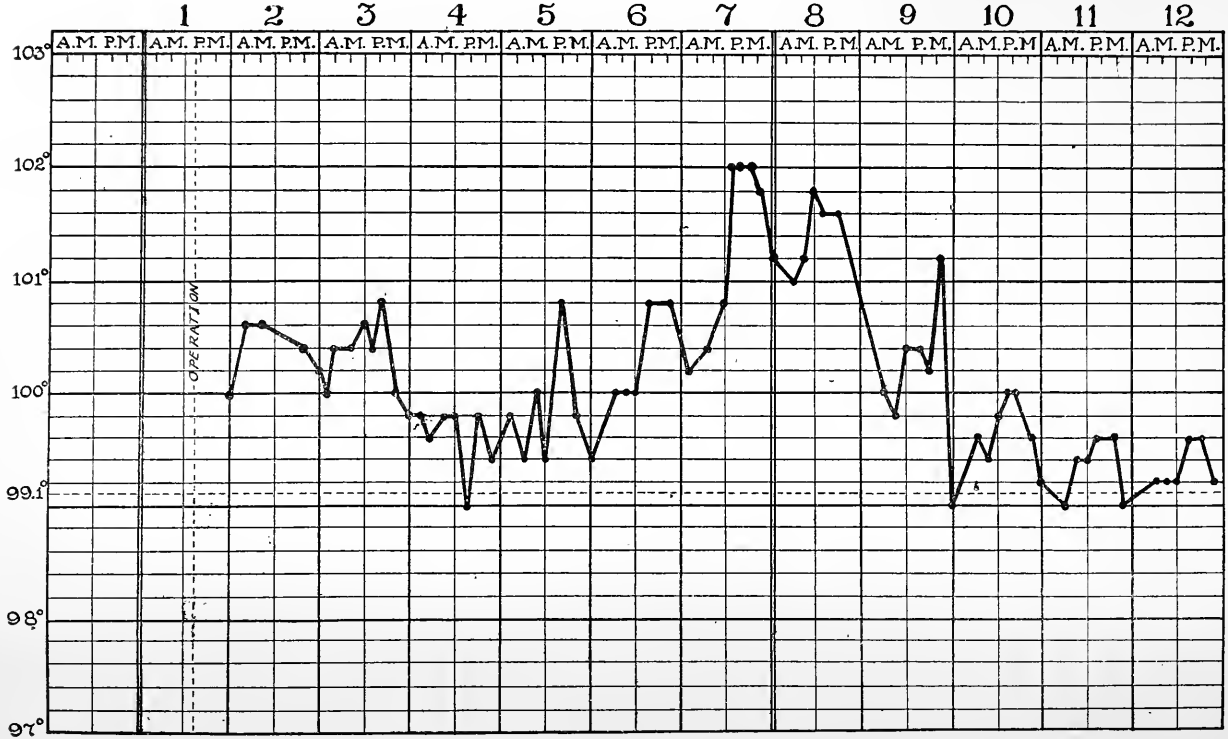


CHART VII~MINOR COMPLICATION DUE TO INFLUENZA NOSTRAS~

NEEF~695~S.S.

CHAPTER XIII

The Treatment of Unclean Wounds

Industrial Wounds

The same principles that hold good for the clean wound which is inflicted by the surgeon in an aseptic operation, are followed in treating the ordinary incised wound of an emergency case. Moisture is congenial to bacterial growth; and clean wounds heal best when they are kept dry. Wounds received in industrial accidents are usually more or less soiled; but the contamination is germless, or at least in most instances, contains no *pathogenic* organisms. When the grime, filth, dirt, tar, paint, axle-grease, and the like have been removed from a laborer's injured hand, it is not uncommon to see healing take place by first intention. A little free bleeding from the cut surface may be the best lavage the wound can receive. Thorough, but gentle rinsing with warm boiled water, is an added precaution. The wound is dried gently, strapped, clamped, or sutured, according to the indication, and a dry, sterile gauze dressing is sufficient.

Unclean and Doubtful Wounds

If, however, contrary to the impression conveyed by the history of the accident, and the appearance, character, and location of the wound, after a few days have elapsed, local redness, tenderness, infiltration of the edges, bacterial discharge, or even perhaps, definite constitutional symptoms, such as headache, malaise, fever, show it to be infected; the plan of treatment for *unclean* or *septic* wounds is instituted at once. In fact, whenever the character of the wound appears *doubtful,* it is an old

but good working-rule, to treat it as if it were infected, until its subsequent behavior gives assurance that it is clean. The wound is held agape, and, after thorough rinsing, drains are introduced and in contradistinction to the treatment of clean wounds, a *wet, mildly antiseptic dressing* is applied.

Tissue-disinfection, that is destruction of bacteria by powerful germicidal solutions, such as formalin, carbolic acid, bichloride of mercury, as it was formerly practiced, should be abolished in the routine care of unclean wounds. It is a different matter when there is reason to suspect inoculation with a dangerously pathogenic organism such as the tetanus bacillus, as when garden-earth or soil has been introduced into the wound. Here local sterilization must be attempted, even at the risk of considerable loss of tissue. The electro-cautory needle or Pacquelin-point are probably most efficacious; next in order, disinfection with pure carbolic acid, which is subsequently limited in its action by the application of alcohol. In either case, tetanus antitoxin is injected circularly about the wound when feasible, after a large dose—not less than 1,500-3,000 units—has been administered intramuscularly in the gluteal region.

Local Sterilization

From a practical point of view, it is convenient to think of *three stages* in the healing of unclean wounds. Firstly, a *stage of infection,* during which the bacterial growth is progressive, the local inflammation more or less acute. Secondly, a *stage of expurgation;* the extension of the infection has ceased, acute symptoms have subsided and the discharge becomes copious. Thirdly, the *stage of aseptic healing,* when a clean, granulating surface appears.

Healing of Unclean Wounds

Stage of Infection and Sedative Dressings

If, during the *stage of infection,* the defensive reaction is marked, and the inflammation is acute, the logical treatment is *sedative.* The most useful of sedative measures in this instance is the moist, mildly antiseptic dressing. Evaporation of the moisture abstracts heat, cools the surface, and makes the patient more comfortable. In general, water which has been modified by the addition of a mild antiseptic, has been used for such dressings, because unmodified water has no inhibiting attributes and might prove to be congenial to bacterial growth. How well this practice is founded is difficult to say. At any rate, very mild antiseptics such as a one to three per cent. aqueous solution of boric acid, while still unfavorable to bacterial development, are, at the same time, in contradistinction to stronger antiseptics, not particularly harmful to the living tissues with which they come in contact.

But the gauze dressing must not be allowed to become dry, if its antiphlogistic effect shall be prolonged. A large dressing remains moist longer than a scanty one. When frequent renewal of the dressing is out of the question, because it is impracticable, as in the large number of dispensary patients; the dressing may be kept moist in the intervals by the external application of weak solutions of boric acid, boro-salicylic acid or aluminum acetate. Another method is based on attempts to retain the moisture by restricting surface evaporation—the wet gauze is covered with rubber tissue or other material which is impermeable to air. To me, the correctness of this procedure, in the case of an acute inflammation, is not thoroughly apparent; for not infrequently, instead of being antiphlogistic and sedative, such a dressing on its removal is found to

be warm and distressing from the retention of heat and foul exhalations.

Stage of Infection and Stimulant Treatment

If, during the stage of infection, the defensive reaction is sluggish, the inflammation is subacute or chronic, measures tending to awaken greater healing response, *stimulant* procedures, are in place. In this connection, the stimulant effect of chemicals on living tissue has to be considered. With chemical substances the stimulation may even, to some degree, be selective. Thus, various aniline dyes are used to stimulate epithelialization; while gauze, impregnated with red wash, and similar solutions, for example, appears to influence more specifically the connective tissue containing granulations, which make up the body of the wound. More recently, experiments on tissue hyperplasia and tumor genesis, have brought to light the fact that innumerable chemical bodies may act as tissue activators.

No doubt the relative inconvenience of applying certain physical agents, such as dry heat from electric lamps, or baking, has been in the way of their wider adoption in the treatment of sluggish wounds. In the main, the utilization of dry heat is more in accord with the general principle, that the healing wound should be kept dry. Here the maceration which is produced by wet procedure, sometimes proves to be an undesirable complication. Thus the stimulant, poulticing effect of a moist dressing covered with rubber tissue, in conjunction with prolonged hot bathing of the part, is contraindicated in the treatment of a wound in the diabetic patient. Moreover, in every instance, it must be borne in mind that where the diminished healing-activity is due to a constitutional cause, no amount

Constitutional and Local Causes of Sluggish Healing

of local stimulation alone, even after the wound has become clean, will suffice to bring about a better healing response. Furthermore, there may be a regional peculiarity, as in varicose veins of the legs. When a wound is inflicted in the compass of the pigmented area, it does not heal readily, because of the pathological vascular condition of the part. Tissue activators, or physical agents, can contribute very little towards wound-healing, if the other, more important measures, directed towards emptying the capillary veins, are disregarded.

With the arrest in the further progress of the infection, the defensive reaction begins to dominate, and the wound-discharge becomes more copious. Wound-discharge is the result of an effort of the wound to expurgate itself. It represents the mass of demarcated and softened tissue about the bacterial focus—a germ-laden, fluid debris which should not remain occluded. Its presence excites exuberant granulations, which disappear when the wound is kept clean and dry.

Stage of Expurgation and Wound Discharge

When the wound is shallow, and above all, when the wound-discharge is scanty, there is no dressing which is better adapted to bring the wound into a healthy condition than plain, dry, loosely woven, aseptic gauze. Occasionally, for practical reasons only, when a wound cannot be dressed as soon as it should be, or the discharge decomposes with exceptional readiness, a dry *antiseptic* gauze may be substituted for the aseptic dressing; or, a dry *deodorant* gauze, when the discharge is foul and disturbing to the patient.

When, however, during the stage of expurgation of the wound, the focal accumulation of pus is more

or less deepseated, and the discharge is profuse, the gauze drain is often of itself unsatisfactory for the purposes of drainage, and adjunct measures become necessary, such as the use of the wound-wedge, rubber tubes, or loop-drains of wire or metal. The reason why dry gauze when employed as a drain is not trustworthy in this instance, is because its fine meshes are rapidly clogged by the inspissated discharge. Thus, not infrequently, what was intended to facilitate drainage, really impedes it, by clogging the wound-outlet like a stopper. The clinical picture is that of retention, and when the gauze is removed the incarcerated pus pours from the wound.

Devices for Aiding Drainage

Since the inspissation of the discharge in the dressing is due to the evaporation of its water content, it is true, gauze drainage can, where this is indicated, be promoted by the use of wet gauze, and by excluding the air by means of rubber tissue to prevent evaporation, or by the continued external application of moisture—methods which are, however, far from being ideal. In *large* wounds the difficulty is overcome by the introduction, in conjunction with the gauze, of two or more soft rubber tubes with a number of lateral openings. In *small* wounds the problem assumes a different aspect. In order to preclude retention in these cases, a twirl of gauze or rubber tissue may be placed in one angle of the wound. This is intended to act, not as a drain, in the strict sense of the word, but rather as a *wedge* which keeps the wound open. Unfortunately this procedure promises more in theory, than its adoption actually merits in practice. The small incision is apt to collapse at the side of the drain; perhaps before the bandage is applied, there exists some uncertainty whether it has not already been dis-

Rubber Tubes

lodged by the premature activity of the awakening patient.

It is essential that a device for keeping small incisions, wounds and sinuses patent, shall not only be slight in bulk, so that it does not obstruct the path of the discharge, but also of such construction, that it can be applied with precision and is not easily displaced. There is a large class of cases, in which the insertion of a drain according to the usual methods is thoroughly unsatisfactory; of these the unfortunate with a suppurative tenosynovitis and many small incisions in the hand, is but one example. A simple, practical method of draining such wounds consists in the introduction into the wound to the desired depth, of loop-drains of thin, flexible metal.

Loop Drains

These drains are nothing more than variously shaped metal loops with flanged ends. The loop is inserted into the recess to be drained, and keeps it open by virtue of the spring-like action of the metal. The grooved flange-ends grasp the sides of the incision, and retain the drain in place. It is practical to keep various sizes sterilized and in readiness for use; also some narrow strips of metal, ⅛th inch wide and upward, in case an anomalous cavity requires that one be improvised. This is easily done if the material is thin commercial "tin." All that is needed is a straight scissors, and an ordinary pair of thumb forceps—instruments which are at hand at every dressing. A long, bent loop-drain may also be used in the *reversed* way in a sinus which is difficult to drain and treat from the bottom. With one, properly applied, it is easier to irrigate the sinus and to introduce disinfectant, antiseptic, or tissue-activating fluids. When a fluid is to be

retained in the sinus it is less difficult to insert a plug into the opening between the metal flanges. In applying the drain the loop is simply closed by nearing the flanges to each other, and introduced into the wound by means of the thumb forceps. The loop is then opened until the lips of the wound are sufficiently separated.

Drains Should Keep the Wound Open

The rubber tube, as well as the metal loop-drain, both *serve the purpose of keeping the wound open,* while the gauze dressing itself, by virtue of its capillarity absorbs the discharge as it escapes from the wound. In some regions, as for example, in the ischiorectal, it is exceptionally important that the draining wound be widely opened, lest the pus burrows in various directions from its original focus, and ischiorectal sinuses and fistulae result.

The Rôle of Chemical Tension

In the appendicitis abscess, when the patient, as is often the case, lies on the back, it is the *chemical tension* alone that causes the pus to rise in the wound, or in the rubber tube which has been inserted into it for drainage. In this instance, the wound-discharge rises *against* gravity until the wound is filled, when it overflows into the gauze dressing. If the tube which was intended to help drainage, projects more or less *vertically* beyond the wound, as such drains generally do, the pus which it contains is simply occluded, and cannot even escape by overflow, since the end of the tube is above the niveau of the pus in the wound cavity. In other words, under such conditions, the tube instead of being helpful, is actually a disadvantage in drainage.

It is clear from this consideration, that drainage produced by chemical tension alone, is *a drainage by overflow and not a drainage from the bottom of the wound.* Chemical tension alone, therefore, is

insufficient to keep the wound dry. Should it now be possible to change the existing conditions, so that the forces of gravity may aid chemical tension, the problem of evacuating the residual pus will find a simple solution. Thus, if an ordinary bottle with a constricted neck were to represent the abscess-cavity, and the water in this container the discharge, the easiest way of emptying it is plainly by allowing the force of gravity to act *directly;* the bottle is turned so that its neck descends below the fluid level. Similarly, gravity may be made to assist drainage, when the wound-opening is brought to a lower level by *postural changes* of the patient. When this is done, the rubber tubes which were previously defunct, begin to drain the recesses into which they have been placed; the drainage, instead of being simply by overflow, takes place from the bottom of the wound.

Gravitation

It is because of the prime importance of gravitation in the expurgation of the unclean wound that, unless anatomically or otherwise contraindicated, the surgeon always opens and drains a suppurating cavity at its most dependent point. Unfortunately the force of gravitation cannot always be made to influence *drainage* directly by low incision or the requisite postural change. In such a case, particularly when the cavity is deep and discharges profusely, *removal of the residual pus by drainage in an uphill direction* must be considered.

First of all, come the methods by which this is attempted by *continuous siphonage.* The laws underlying drainage by siphonage, can be illustrated by means of a bottle containing water and a long drainage tube. As the tube rests upon the edge of the bottle, one end immersed in the water, while

Continuous Siphonage

the other is outside, an ascending limb within, and a descending limb of the drainage tube without, may be distinguished. But in spite of the fact that the end of the descending limb is considerably lower than the level of the fluid within the bottle, no drainage takes place. Suction, or more accurately speaking, the production of negative pressure within the tube sufficient to raise the column of water to its highest point over the edge of the bottle, is essential to start the flow. When the water has once reached the descending limb, it readily escapes by gravitation. But the gravitating column produces renewed suction behind it, which causes a second charge of fluid to rise in the tube. Thus siphonage, once instituted, may continue indefinitely until the bottle has been emptied of its contents.

If, in such an experiment, the tube is replaced by a piece of gauze, similar observations can be made. The drain may remain indefinitely without causing a flow of fluid from the bottle. The capillary attraction of the gauze alone is insufficient to carry the water to a point where gravity can begin to act. If, however, suction is started, by pouring water down the descending limb, siphon-action can be initiated which continues until the bottle is empty. Unfortunately, these laws of drainage, striking as they may be in the experiment, have but a very limited application in surgical drainage. Most devices in which siphonage is produced by running water, or by means of an interpolated rubber bulb, or large reservoir from which the air has been exhausted, and which have for their object *continuous* drainage in the strict sense of the word, are anything but practical. The ordinary suction cup, it is true, may be kept on a discharging wound for a long time;

but its action becomes feeble as the vacuum disappears. It is really better adapted for inducing local hyperemia, than for encouraging drainage. In practice, therefore, the disposal of the residual pus in instances in which uphill drainage cannot be avoided, resolves itself into efforts at repeated and thorough *evacuation at the time of the dressing* by means of one of two simple methods, either *suction* or *expression.*

The Expression Method

In the *expression method,* the accumulated discharge is emptied by gentle compression and manipulation of the pus undermined territory, by means of the fingers of the gloved hand. When properly carried out, it is unattended by any traumatism to the wound. In contra-distinction to the suction method, it has the great advantage that it is simpler in execution, and no special apparatus is required. The notion that pus may in some way be forced into the blood vessels by this procedure, is erroneous. With all its simplicity, it is none the less efficient. It is applicable nearly everywhere where the tissues can be grasped or manipulated with the fingers, and the surface structures are not too rigid and unyielding.

In the treatment of the non-tuberculous submaxillary abscess which is so common in the improperly cared for children of the poor under three years of age, and is due to pyogenic infection from the mouth, the use of the expression method is typically illustrated. A little ethyl chloride sprayed on the mask, or a few drops of anaesthol or of ether, just sufficient for a primary anesthesia; a small incision through the skin, parallel to the natural folds in the neck and over the fluctuating point or the spot of greatest softening; penetration

of the soft parts and abscess-wall bluntly, by means of a small forceps, while the tissue is fixed between the thumb and fingers of the left hand; separation of the blades of the forceps to widen the opening into the abscess cavity; simultaneous compression or "milking" of the infiltrated area from without, until no more pus appears; insertion of a metal loop-drain to keep the small opening patent; a large dressing of loose sterile gauze. If expression has to be repeated one or more times at subsequent dressings, this can be done without causing much pain, because the inflammation is no longer acute, as when the abscess was first incised; neither does a forceps have to be introduced into the wound, because the drain keeps open the way for the escaping discharge. In this procedure, the *protective lining of the abscess cavity is conserved* as far as possible; indeed, the use of the curette within *any* abscess cavity is obsolete.

The Suction Method

The *suction method* varies widely in its application in the hands of different surgeons. It seems vital, that whatever device is used for this purpose, the degree of suction can be regulated at will; for, in the ordinary suction cup, the vacuum is soon destroyed. A serviceable mechanism can be improvised by pushing one end of a rubber tube which is about eight inches long and has an internal diameter of about ⅛ inch, into the open connecting arm of a small glass suction cup; while the other end is slipped over the *air-inlet* arm of an ordinary suction pump, such as is used, for example, to create a vacuum in the flask of a Potain apparatus for aspirating the chest. The *air-outlet* arm of the suction pump is left open. The most useful cup for routine work, is one which measures about two

inches in diameter and has the shape of a miniature bell-jar (F. A. Eschenbaum, Bonn). The suction pump itself is all metal, and every part of the apparatus, tube, cup and pump can be sterilized by boiling with the dressing instruments. The nurse manipulates the pump while the suction cup is held snugly applied to the surface over the wound from which the pus is to be exhausted. The skin becomes hyperemic, is drawn into the cup, and as the vacuum is intensified by continued pumping, the discharge begins to flow from the orifice of the wound. In an unclean post-operative case where the sutures have become infected by the staphylococcus, for example, considerable yellow, odorless pus is at first obtained, two to four ounces perhaps, while later the wound discharge becomes scantier, thin and serous, and shreds of sloughing fascia or the black knots of chromicized catgut partly digested, may be observed to pop through the small drainage opening in the incision-line, into the negative space, under the powerful influence of the suction.

When finally an unclean wound has expurgated itself, the discharge has ceased, or is scanty and sterile, and a healthy, granulating surface presents, the *stage of aseptic healing has been reached, and closure of the wound by apposition may be attempted, in the hope of securing union, just as in the cases in which the wound was clean from the beginning.*

The Stage of Aseptic Healing

CHAPTER XIV

Conclusion

Ready and reliable surgical judgment is cultivated by repeated reflection on surgical experiences. In this, a common case may sometimes teach more that is of practical importance, than the exceptional one. Information which is obtained from others and from books, is of great value, but it is very often not half so determining in its influence on surgical reasoning, as one single error which is self-committed. If, in spite of every preliminary, the surgeon meets with an unfortunate experience which is due to an error in his judgment, he cannot conscientiously pass it by without much thought.

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